NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT No. 380

PRESSURE DISTRIBUTION OVER THE FUSELAGE OF A PW-9 PURSUIT AIRPLANE IN FLIGHT

By RICHARD V. RHODE and EUGENE E. LUNDQUIST

1931

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AERONAUTICAL SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Symbol	Unit	Symbol
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	s	second (or hour)	sec. (or hr.)
Force	F	weight of one kilogram	kg	weight of one pound	lb.
Power	P	kg/m/s		horsepower	hp
Speed		km/h	k. p. h.	mi./hr.	m. p. h.
		m/s	m. p. s.	ft./sec.	f. p. s.

2. GENERAL SYMBOLS, ETC.

W, Weight $=mg$

g, Standard acceleration of gravity $=9.80665$ m/s$^2=32.1740$ ft./sec.^{2}

m, Mass $=\frac{W}{g}$

ρ, Density (mass per unit volume).

Standard density of dry air, 0.12497 (kg-m^{-4} s^2) at 15° C. and 750 mm $=0.002378$ (lb.-ft.$^{-4}$ sec.^{2}).

Specific weight of "standard" air, 1.2255 kg/m$^3=0.07651$ lb./ft.^{3}.

mk^2, Moment of inertia (indicate axis of the radius of gyration k, by proper subscript).

S, Area.

S_w, Wing area, etc.

G, Gap.

b, Span.

c, Chord.

$\frac{b^2}{S}$, Aspect ratio.

μ, Coefficient of viscosity.

3. AERODYNAMICAL SYMBOLS

V, True air speed.

q, Dynamic (or impact) pressure $=\frac{1}{2}\rho V^2$.

L, Lift, absolute coefficient $C_L=\frac{L}{qS}$

D, Drag, absolute coefficient $C_D=\frac{D}{qS}$

D_o, Profile drag, absolute coefficient $C_{D_o}=\frac{D_o}{qS}$

D_i, Induced drag, absolute coefficient $C_{D_i}=\frac{D_i}{qS}$

D_p, Parasite drag, absolute coefficient $C_{D_p}=\frac{D_p}{qS}$

C, Cross-wind force, absolute coefficient $C_C=\frac{C}{qS}$

R, Resultant force.

i_w, Angle of setting of wings (relative to thrust line).

i_t, Angle of stabilizer setting (relative to thrust line).

Q, Resultant moment.

Ω, Resultant angular velocity.

$\rho\frac{Vl}{\mu}$, Reynolds Number, where l is a linear dimension.

e. g., for a model airfoil 3 in. chord, 100 mi./hr. normal pressure, at 15° C., the corresponding number is 234,000;

or for a model of 10 cm chord 40 m/s, the corresponding number is 274,000.

C_p, Center of pressure coefficient (ratio of distance of $c.\ p.$ from leading edge to chord length).

α, Angle of attack.

ϵ, Angle of downwash.

α_o, Angle of attack, infinite aspect ratio.

α_i, Angle of attack, induced.

α_a, Angle of attack, absolute.
(Measured from zero lift position.)

γ, Flight path angle.

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PRESSURE DISTRIBUTION OVER THE FUSELAGE OF A PW-9 PURSUIT AIRPLANE IN FLIGHT

By RICHARD V. RHODE and EUGENE E. LUNDQUIST
Langley Memorial Aeronautical Laboratory

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

NAVY BUILDING, WASHINGTON, D. C.

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REPORT No. 380

PRESSURE DISTRIBUTION OVER THE FUSELAGE OF A PW-9 PURSUIT AIRPLANE IN FLIGHT

By Richard V. Rhode and Eugene E. Lundquist

SUMMARY

This report presents the results obtained from pressure distribution tests on the fuselage of a PW-9 pursuit airplane in a number of conditions of flight. The investigation was made to determine the contribution of the fuselage to the total lift in conditions considered critical for the wing structure, and also to determine whether the fuselage loads acting simultaneously with the maximum tail loads were of such a character as to be of concern with respect to the structural design of other parts of the airplane. The tests were conducted by the National Advisory Committee for Aeronautics at Langley Field, Va., during the spring of 1929.

The results show that the contribution of the fuselage toward the total lift is small on this airplane, ranging from slightly less than 3 per cent at the lower angles of attack to about 4 per cent at the higher angles, which approximately compensates for the portion of the wing area replaced by the fuselage. Aerodynamic loads on the fuselage are, in general, unimportant from the structural viewpoint, and in most cases they are of such character that, if neglected, a conservative design results. In spins, aerodynamic forces on the fuselage produce diving moments of appreciable magnitude and yawing moments of small magnitude, but opposing the rotation of the airplane.

A table of cowling pressures for various maneuvers is included in the report.

INTRODUCTION

Little information exists concerning the magnitude and distribution of the aerodynamic loads which occur on airplane fuselages in the various conditions of flight. While these loads have generally been considered small and of little interest to the designer, there have been some indications that in certain of the critical loading conditions the fuselage loads are appreciable and might justify their consideration in the design specifications. This is particularly true of the high angle of attack condition in which tests on the MB-3 (reference 1) indicated that the fuselage supported approximately 10 per cent of the total load. In the MB-3 tests, however, as in all pressure distribution tests involving only the wings or wings and tail surfaces, the fuselage load must be determined by subtracting the sum of the wing and tail loads from the product of the weight of the airplane and the applied load factor as determined from an accelerometer. This method is, of course, crude, and fuselage loads so determined include the errors from the wing and tail loads as well as the error from the accelerometer. The error in the fuselage load, therefore, is excessive.

It was thought advisable, in view of the lack of information on the subject, to measure the loads on a fuselage directly by means of pressure distribution tests. Differential pressures, both normal and transverse, were therefore measured except on the engine and radiator cowlings where special conditions made it necessary to measure pressures on each surface separately.

Although, at present, pressure distribution tests are the only practicable method of measuring aerodynamic loads in flight, they can be used to determine such loads with good precision only on surfaces having smooth contours such as airfoils. On fuselages, which have numerous points of discontinuity such as those at the radiator, windshield, cockpit, etc., results from pressure distribution tests can be considered at best only approximate, unless an impracticably complete installation of pressure orifices is used. However, since the aerodynamic loads on fuselages are manifestly of secondary importance in design, great accuracy is not essential to the practical value of the results.

APPARATUS AND METHOD

The airplane used in these tests was a modified PW-9 pursuit airplane. (Fig. 1 and Table I.) From the standpoint of the results, the modifications were not important, consisting, principally of the substitution of a balanced and larger rudder for the original one and a complete metal cover for the fuselage. These changes were made in order to increase the directional stability which had been poor, and to facilitate the installation and maintenance of the pressure tubes and orifices. The changes in the weight and *c. g.* location from their former values were negligible and had no influence on the results.

Two views of the tubing installation are shown in Figures 2 and 3. This installation was practically the same as those used in other full-scale pressure distribution investigations at Langley Field (refer-

ences 1 and 2), in that the orifices were connected in pairs to the manometer, and differential pressures, that is, pressure differences between upper and lower and right and left surfaces, were measured over most of the fuselage. Exceptions to this procedure were necessary in some cases, however, because of special conditions. At the cockpit, for instance, the normal or "vertical" pressures were measured between the flush orifices on the lower outer skin and static orifices inside and beneath the flooring. On the nose, forward of the fire wall, differential pressures between two sides of the fuselage do not give the true resultant load because of the existence of an internal pressure gradient caused by the flow of air through the radiator shell. For this reason pressures on the engine cowling were measured directly between the external flush orifices and special static orifices mounted just inside and opposite to them. On the radiator cowling a different procedure had to be followed, since the air velocities were high inside the cowling. Here a double-skin cowling was used and differential pressures measured between opposite flush orifices in the double-skin. The engine and radiator cowling installation is shown diagrammatically in Figure 4.

The instruments used in these tests consisted of the following:

(*a*) Two N. A. C. A. type 60 recording multiple manometers (reference 2).

(*b*) Air-speed meter (reference 3).

(*c*) Single-component accelerometer (reference 4).

(*d*) Turnmeter (reference 5).

(*e*) Control-position recorder (reference 6).

(*f*) Timer (reference 7).

All these instruments, with the exception of the timer, give continuous photographic records over a period of time sufficient to completely include any maneuver. They are synchronized by means of the timer which completes an electrical circuit periodically (in these tests at 1-second intervals) and causes vertical timing lines to be imposed on all records simultaneously.

As it was desired to determine the time relation between the fuselage loads and the tail loads, and because of the impracticability of measuring the tail loads during these tests, two pairs of orifices (S and T, indicated in the results) were installed in the leading edges of the stabilizer and elevator, respectively. Previous tests on the PW-9 (reference 8) had indicated that the sum of the pressures on the leading edges of the stabilizer and elevator varied roughly in the same manner as the total tail load. Thus, the curve of S+T in this report shows the trend of the load on the horizontal surfaces, but is not a measure of it.

It will be noted in Figure 18 of the results that the fuselage characteristics are plotted against angle of attack. The angle of attack, for this purpose, was obtained indirectly, no instrument being available for measuring it during the tests. The method used for obtaining it involved a knowledge of the acceleration, air speed, weight, and slope of the lift curve of the airplane, all these quantities except the last being measured directly.

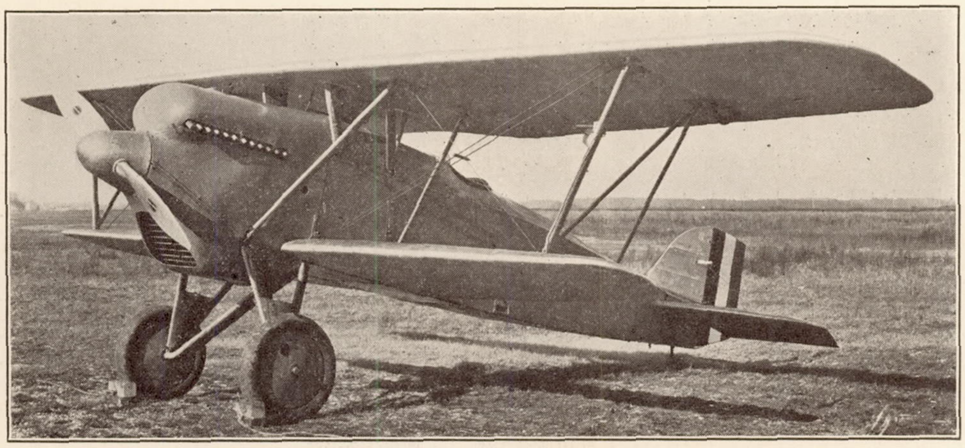

FIGURE 1.—PW-9 airplane

Since

$$\frac{W}{g}n = a\ \alpha_a S \tfrac{1}{2}\rho V^2$$

where

n = acceleration,

a = slope of lift curve,

α_a = absolute angle of attack,

it follows that

$$\alpha_a = \left(\frac{W}{Sa}\right)\left(\frac{2n}{\rho V^2 g}\right),$$

this equation being applicable below the stall.

Points on the curve of Figure 18 were taken from all the maneuvers investigated except rolls and spins.

PRECISION

The precision of the results of these tests is not great. With the installation used, individual pressures are correct to within ±6 to 8 per cent, air speeds

within ±3 to 4 per cent, and accelerations within ±0.2 *g*. Total loads and moments, which depend upon the integration of curves faired through relatively few points obtained from pressure measurements on a surface having a number of discontinuities, can be considered at best only fair approximations. An estimation of the precision of these loads and moments is somewhat hazardous, but it is probable that individual total loads are correct to within about 20 per cent. Moments about the center of gravity for any one instant, being extremely sensitive to slight changes in fairing the load curves, are probably not reliable to the point of usefulness at all; but taken collectively, however, as in Figure 18, a good idea of the trend of the moment coefficient can be obtained as well as a fair idea of its absolute value.

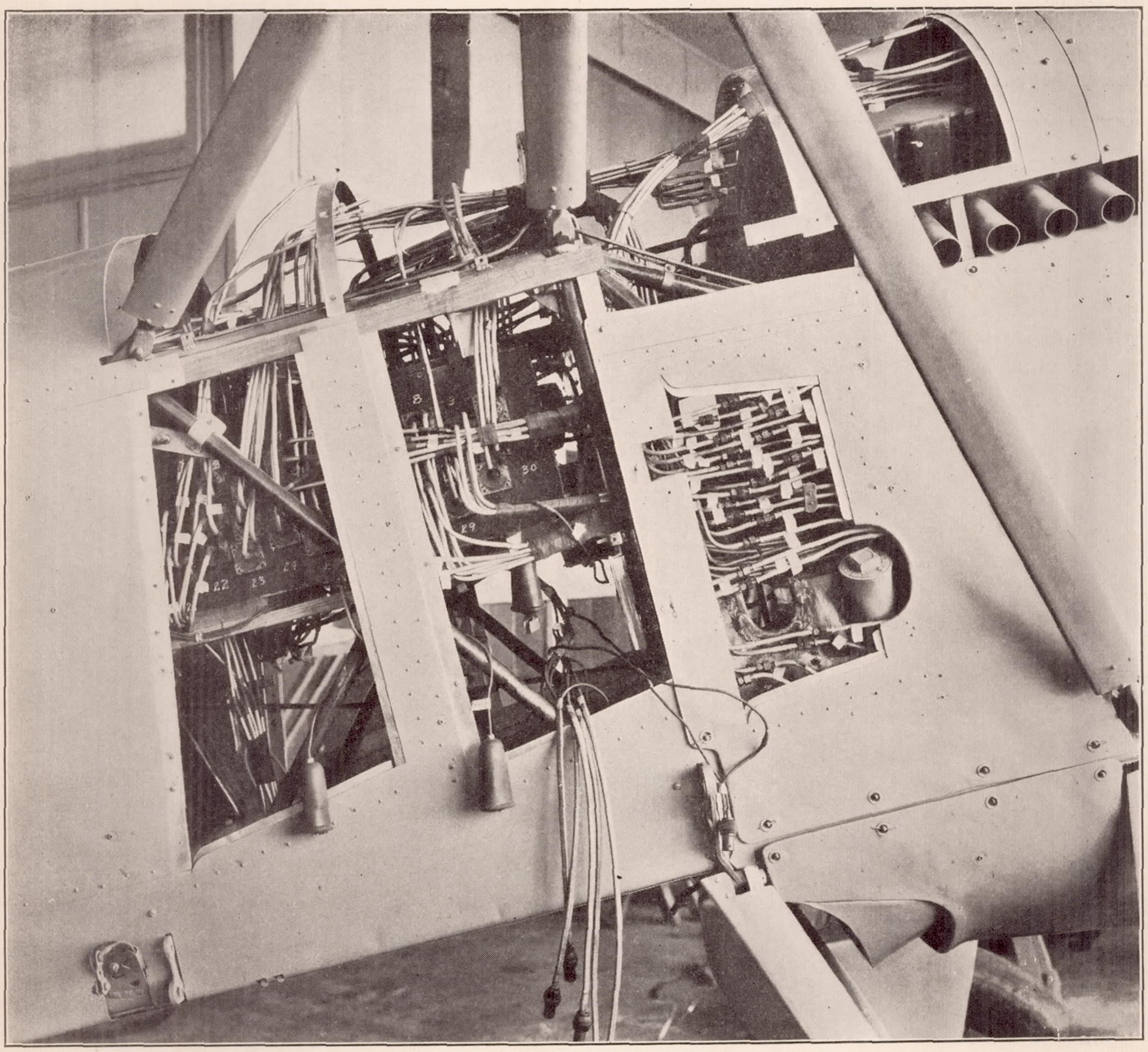

FIGURE 2.—Manometer installation showing pressure tubes connected

RESULTS

The results following are given in the form of load curves, histories of maneuvers, and fuselage characteristic curves. The detailed distribution of pressure is not presented because, in view of the purpose of this investigation, viz, to determine the importance of fuselage air loads in critical design conditions, such a presentation is considered unnecessary and of little interest. Engine cowling pressures are, however, given in tabular form for a number of conditions, since these pressures are at times of sufficient magnitude to be of interest with respect to cowling strength.

Results are discussed in the following sequence:

(*a*) Steady flight conditions.
(*b*) Pull-ups.
(*c*) Rolls and spins.
(*d*) Cowling pressures.

Steady flight conditions.—The steady flight conditions investigated include only those involving motions of translation without yaw. Thus, they are restricted to level flight and dives or steep glides. In these conditions of flight, as would be expected, no appreciable transverse aerodynamic forces on the fuselage existed. The results given, therefore, refer only to normal loads or those parallel to the *Z* axis of the airplane.

Figure 6 shows the distribution of normal load along the fuselage in level flight at air speeds from 78 to 166 m. p. h., corresponding to angles of attack ranging from about 8° to −2.2°. All these curves are quite similar in character and are of interest mainly because they show pronounced interference effects in the region of the upper wing, viz, from stations 5 to 9 feet. The reduction in load at the radiator location, 1.25 feet, is also clearly indicated. This latter depression is partly a result of the fact that no pressure measurements could be taken on the radiator itself, the curve in this region depending on pressure measurements taken only on the upper surface of the fuselage. There is probably some upward force on the radiator, and if this could have been included, the reduction of load at this location would not have appeared so pronounced.

In Figure 7 are given the normal load curves for two dives at 200 m. p. h., one with power on, and the other with power off. No appreciable difference can be noticed in the two curves except for a slight increase in the down load or interference at the wing location for the power-on condition, probably a result of slightly higher velocity in the slipstream.

Pull-ups.—Of a series of abrupt pull-ups from level flight and several mild pull-outs from vertical dives, only a few representative cases are presented because of the general similarity of all. Load curves for successive stages of the pull-out from a vertical dive are given in Figure 8. The similarity of the curves is at once apparent and also their similarity to the curves obtained in level flight. There is, however, a distinct tendency for the load near the nose to increase with increasing angle of attack or as the maneuver progresses. The history of this maneuver is better shown in Figure 9. As will be noticed from the acceleration record, this run starts with the airplane well into the

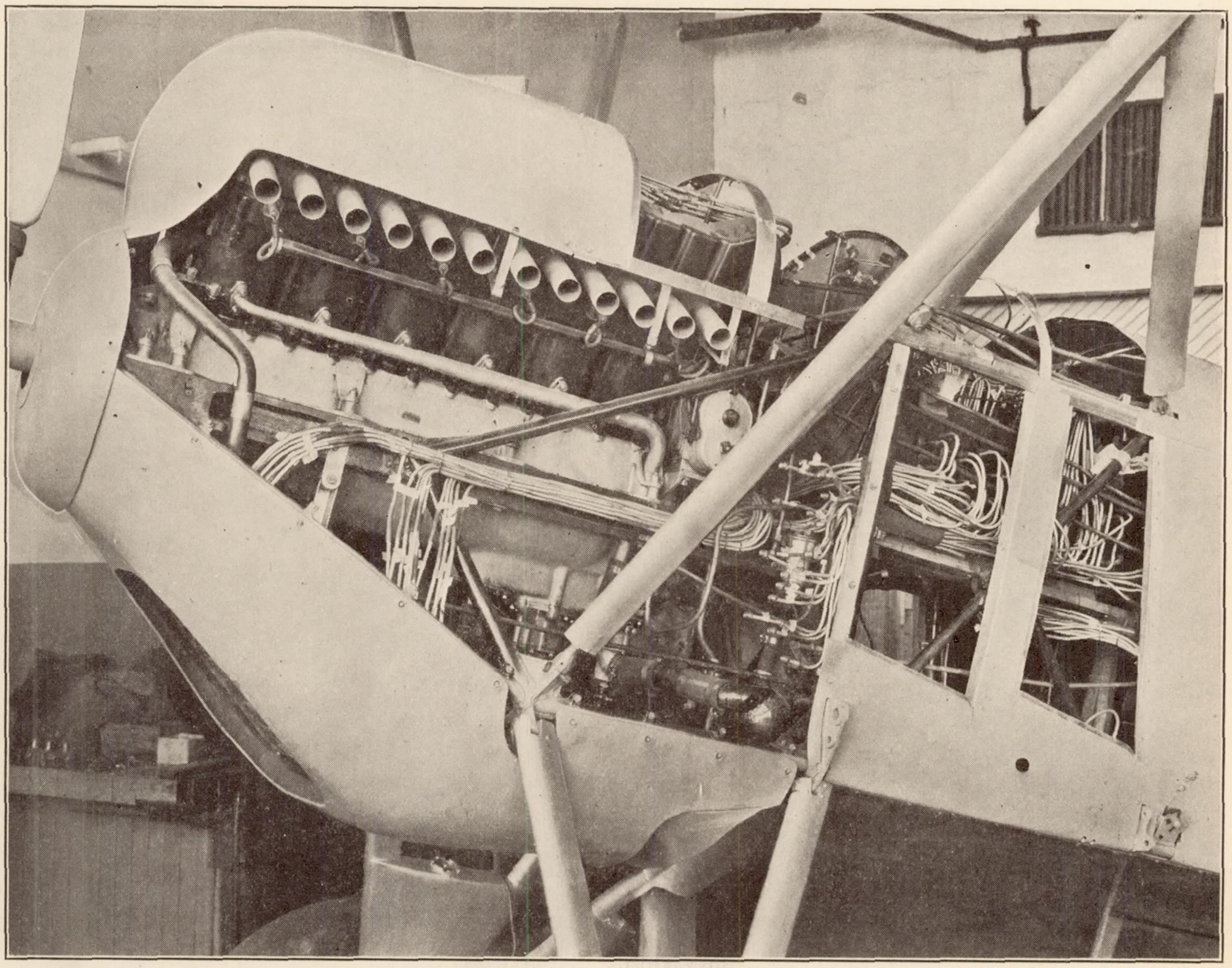

FIGURE 3.—Cowling pressure tube installation

dive, near zero lift; the pull-out, however, immediately taking place. From these results and the results obtained in previous pressure distribution tests on this airplane, an idea of the extent to which the fuselage load affects the stresses in the fuselage and wing structures can be obtained. In the dive itself the total normal load on the airplane is of little interest, since it is essentially zero. A heavy wing-diving-moment exists, however, which must be balanced by a moment supplied by the tail and the fuselage. Normally this will be the case, although it is quite possible that the wing and fuselage moments will add up in the same sense and require a larger tail moment in consequence. From Reference 8 it is found that the tail load is 916 pounds acting down in a dive at 260 m. p. h. The corresponding tail moment about the *c. g.* is, therefore, approximately 13,000 pound-feet for this speed. Assuming the attitude of the ship and angle of attack to be approximately the same for the dive given here, this result should be corrected according to the ratio of the speeds squared. On this basis the tail moment becomes $13{,}000\times\left(\frac{192}{260}\right)^2$ or 7,100 pound-feet. The total moment arising from air loads on the fuselage for this case is 640 pound-feet or 9 per cent of the tail moment, which means that the fuselage reduces the tail load necessary to balance the airplane by about 8¼ per cent. If it is assumed that the design tail load for the nose dive condition is determined from a knowledge of the true wing moments, neglecting the effect of the fuselage, the structure will be conservatively designed throughout.

In pull-outs of this character, tail loads normally decrease from their original high negative values and become positive in sense, as indicated by the curve (S+T), the positive values usually being less than those encountered in certain other maneuvers, as, for instance, the barrel roll. Hence, the contribution of the fuselage loads toward the total moments acting in such pull-outs are of no practical importance and need not be considered. In all pull-outs, however, the wings commence to acquire an appreciable normal component of force in the same direction as the normal component of force on the fuselage, and this wing load largely determines the design of the wing structure. It is seen from Figure 9 that throughout the pull-out, in which maximum lift was never reached, the proportion of the total load carried by the fuselage throughout the maneuver is slightly less than 3 per cent so that for any low angle of attack condition the fuselage load need not be considered in the wing design.

Figures 10 and 11 show the load curves for two representative abrupt pull-ups from level flight, one with power on and the other with power off. In these maneuvers the angle of attack of maximum wing lift was reached and exceeded; the load curves for these higher angles show that the interference from the upper wing was reduced or that it was of smaller magnitude with respect to other effects, so that the fuselage load was positive throughout its length. Differences between power-on and power-off conditions were found to be slight.

Histories of several pull-ups are given in Figures 12 to 17. In the high angle of attack loading condition, represented by the instant of maximum acceleration, the proportion of the total normal load carried by the fuselage varies from 3.75 to 4.5 per cent, an amount which reduces the wing load in a maneuver involving an acceleration of 6, or half the design load factor, by approximately one-quarter of a load factor. Put in another way, this means an increase in margin of safety of from 1 to about 1.04 on the basis of loads, an increase hardly worth allowing for in the wing design.

A more accurate idea of the load the fuselage carries can be obtained by referring to Figure 18. The normal force coefficient of the fuselage is seen to vary lineally

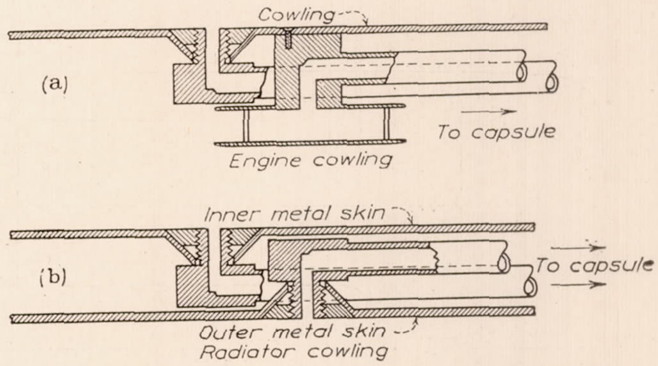

FIGURE 4.—Diagram of orifice arrangement on engine and radiator cowling

with angle of attack, reaching zero at −4°. The equation of this line is found to be $C_N=0.01613\ (\alpha+4)$.

Since the C_N versus α curve for the wing cellule is also approximately a straight line whose equation is $C_N=0.0702\ (\alpha+5.5)$, the ratio of the fuselage load to the wing load is

$$\frac{L_f}{L_w}=\frac{C_{N_f}A_f}{C_{N_w}A_w}$$
$$=\frac{0.01613\ (\alpha+4)}{0.0702\ \ (\alpha+5.5)}\times\frac{40.8}{241.2}.$$

From this, L_f/L_w at zero angle of attack is 0.0283 and at 20° is 0.0368. The values obtained from the above formula for the higher angles of attack are slightly low since the wing lift curve is not straight up to the stall, but starts to fall off several degrees earlier. Hence, at the high angles of attack the ratio of fuselage to wing load is closer to 0.04. There is a possibility that beyond the stall C_N for the fuselage continues to increase for a small range of angle of attack which would result in a more rapid increase in load ratio. There is some indication that this is true in the results of Figures 12 to 17, for the load ratio curves show a tendency to rise after the peak acceleration in some cases, although the

accuracy of the data does not warrant definite conclusions. In any case the phenomenon would have no practical significance from the structural standpoint.

It is of interest to note that the loss in true wing area caused by the replacement of the middle of the lower wing with the fuselage is approximately compensated for by the fuselage itself. The wing area displaced by the fuselage on the PW–9 is 12 square feet or almost 5 per cent of the total area. Thus the lift might be expected to be reduced by 5 per cent, but the loss is partly compensated for by the fuselage lift which ranges from about 3 to 4 per cent of the total. The common assumption in performance calculations, that the wing area displaced by the fuselage has not in effect been lost, is, therefore, fairly sound. For the sake of consistency this assumption might also be carried to the structural load problems, but would probably be unwise because it would remove a slightly conservative factor in the design.

Abrupt pull-ups such as these under discussion, in addition to giving rise to large wing loads at high angles of attack, also involve a suddenly applied tail load which may be critical for some members of the fuselage in some designs, usually for the lower longerons aft of the lower wing rear spar attachment and for some of the diagonal truss members in designs where the tail load in the terminal dive is of less magnitude than this suddenly applied load in the pull-up. In such cases it is of interest to know the relation of the fuselage load aft of the *c. g.* to the tail load, and in particular the relative magnitudes and directions of moments about the *c. g.* arising from fuselage and tail loads acting at the same instant. From an examination of the histories given in Figures 12 to 17 it is seen that early in each maneuver when the tail load is at a maximum negative value, the fuselage loads aft of the *c. g.* are very small and for practical purposes, zero. Moments, on the other hand, while small, are definite but always negative in sign, opposing the moments arising from the tail loads. The magnitudes of these loads and moments are not sufficient to be of concern with respect to stresses in the fuselage, but in so far as they do exist, are of such a character as to reduce slightly the moments and shears arising from the tail load.

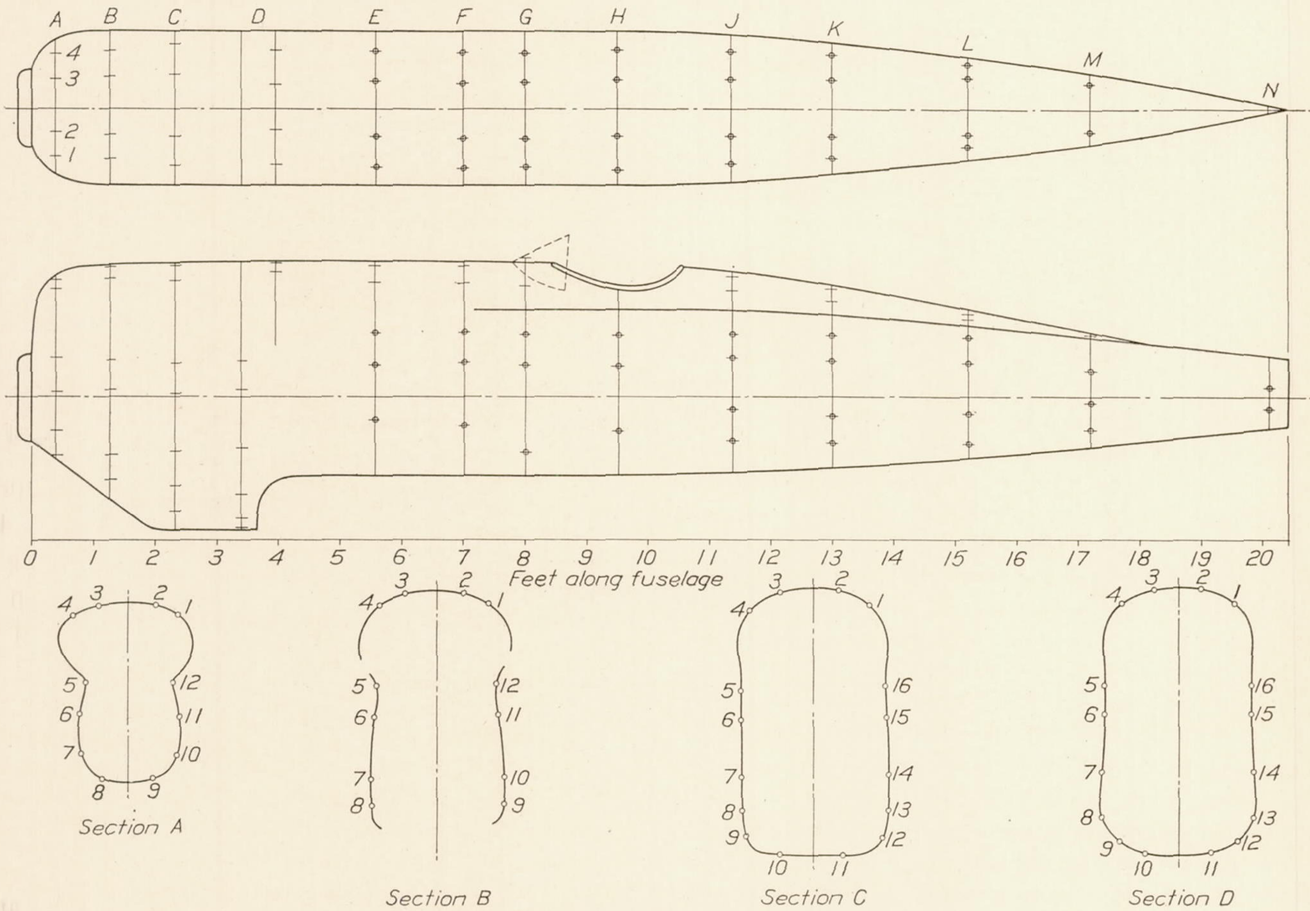

FIGURE 5.—Line diagram of fuselage showing orifice locations

In the later stages of the pull-up, when the tail load has reached a maximum positive value, the relative fuselage loads become of greater apparent importance. It has been pointed out in reference 8 that the maximum up loads on the tail in abrupt pull-ups are only of the order of half the maximum down loads on this airplane. Since the 3-point landing condition generally induces greater fuselage stresses than the relatively low positive tail load considered alone, this

latter case is not usually considered except in cases where a tail skid is not required, as on a single or twin float seaplane. The results of this investigation (figs. 12 to 17) show, however, that the up tail loads may be accompanied by fuselage loads of such character that the total aerodynamic loads and moments are considerably greater than those of the tail alone. From the results of Figure 38, reference 8, and Figure 14 of this report, both being time histories of abrupt pull-ups at about 155 m. p. h., an idea of the magnitudes of these fuselage loads and moments can be obtained. while the moment is greater for the case of maximum negative tail load. A discussion of the importance of aerodynamic forces on the tail and fuselage is not complete without a proper consideration of the inertia forces acting at the same time. In the condition of maximum negative tail load there exists a positive angular acceleration in pitch which tends to reduce or in some cases possibly to nullify the effect of gravity on masses in the after end of the fuselage. Hence, to assume the maximum tail load as acting when all masses aft of the lower rear wing spar,

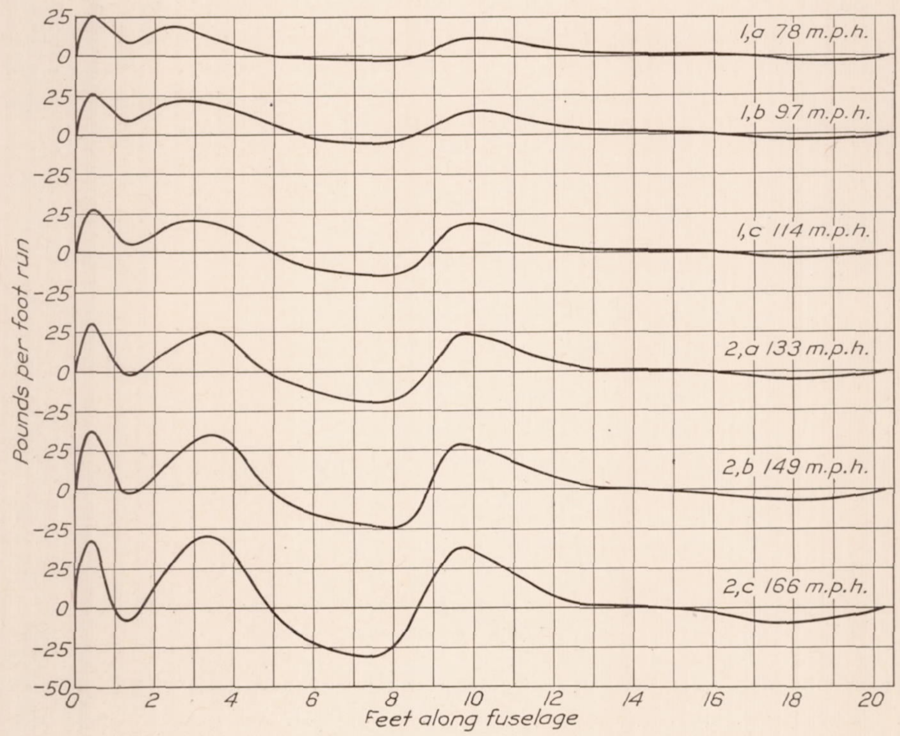

FIGURE 6.—Fuselage normal load curves. Level flight runs. Run No. 4

CONDITION OF MAXIMUM NEGATIVE TAIL LOAD

	Shear [1] (at c. g.)	Moment [1] (about c. g.)
	Pounds	*Pound-feet*
Tail	−680	+10,000
Fuselage	+50	−280
Total	−630	+9,720

CONDITION OF MAXIMUM POSITIVE TAIL LOAD

	Shear [1] (at c. g.)	Moment [1] (about c. g.)
	Pounds	*Pound-feet*
Tail	+330	−4,000
Fuselage	+390	−2,000
Total	+720	−6,000

[1] Fuselage shears and moments refer to those arising from loads aft the c. g.

It is seen from the above that the total shear is greater for the condition of maximum positive tail load

are acted upon normally by gravity is conservative. In the condition of maximum up tail load on the PW-9 there still exists a positive angular acceleration in pitch. This is easily explained by the existence of a large wing force vector whose line of action is forward of that for the resultant mass force. In addition to this angular acceleration, there is also a linear acceleration acting in a direction which is, for all practical purposes, parallel to the Z axis and of a magnitude equal to or quite close (in terms of "g") to the applied high angle of attack load factor. This linear acceleration is of much greater consequence than the angular acceleration, so that the net result, so far as the stresses in the after portion of the fuselage are concerned, is an inertia force opposing the aerodynamic up load on the tail and fuselage. This inertia force is, in fact, so large that in most cases, except where very light fuselage and tail assemblies are used, it is greater than the aerodynamic up load so that this latter condition is by no means to be

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considered a true criterion for the design of the fuselage structure.

Rolls and spins.—Load curves and histories of right and left barrel rolls and spins are given in Figures 19 to 26. In so far as normal loads in the rolls are concerned, conditions are quite similar in character to those in the abrupt pull-ups and a similar discussion applies. In the rolls, however, transverse loads as well as normal loads are experienced. An extended analysis of the effects of these loads is not considered worth while mainly because of the lack of quantitative information on the inertia loads and vertical tail surface loads acting simultaneously with them. A rough quantitative analysis of the lateral forces and moments on the basis of fuselage loads obtained during this investigation and tail surface and inertia loads obtained in the tests of reference 8 and others shows that none of these forces and moments are of sufficient magnitude to be of concern with respect to the fuselage design except the initial, suddenly applied vertical tail load, which may be considered, for practical purposes, to act alone.

In the spins no loads of any magnitude sufficient to be of concern in the structural design are evident. It is interesting to note, however, in the histories of the spins that an appreciable diving moment is present as a result of air loads on the fuselage and that lateral loads, although small in magnitude, are, in the main, of such a character as to oppose the rotation of the airplane.

Cowling pressures.—Engine cowling pressures for the maneuvers given previously are tabulated in Table II. Since skin pressures are higher near the nose than elsewhere, this information is of interest with respect to the design of the engine cowling panels and their attachments. In interpreting this table, positive pressures are to be considered acting inwardly and negative pressures outwardly.

CONCLUSIONS

1. The proportion of the total normal load carried by the fuselage of the PW–9 ranges from slightly less than 3 per cent in the low angle of attack design condition to about 4 per cent in the high angle of attack condition which approximately compensates for the loss of lift of the portion of the wing area replaced by the fuselage.

2. Aerodynamic loads on the fuselage are, in general, unimportant from the structural viewpoint, and in most cases they are of such character that, if neglected, a conservative design results.

3. In spins, aerodynamic forces on the fuselage produce diving moments of appreciable magnitude and yawing moments of smaller magnitude opposing the rotation of the airplane.

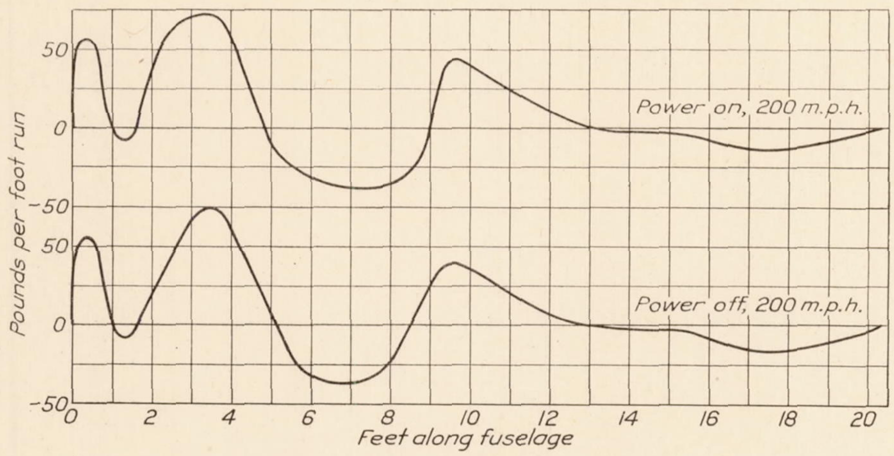

FIGURE 7.—Fuselage normal load curves. Dives

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
LANGLEY FIELD, VA., *August 1, 1930.*

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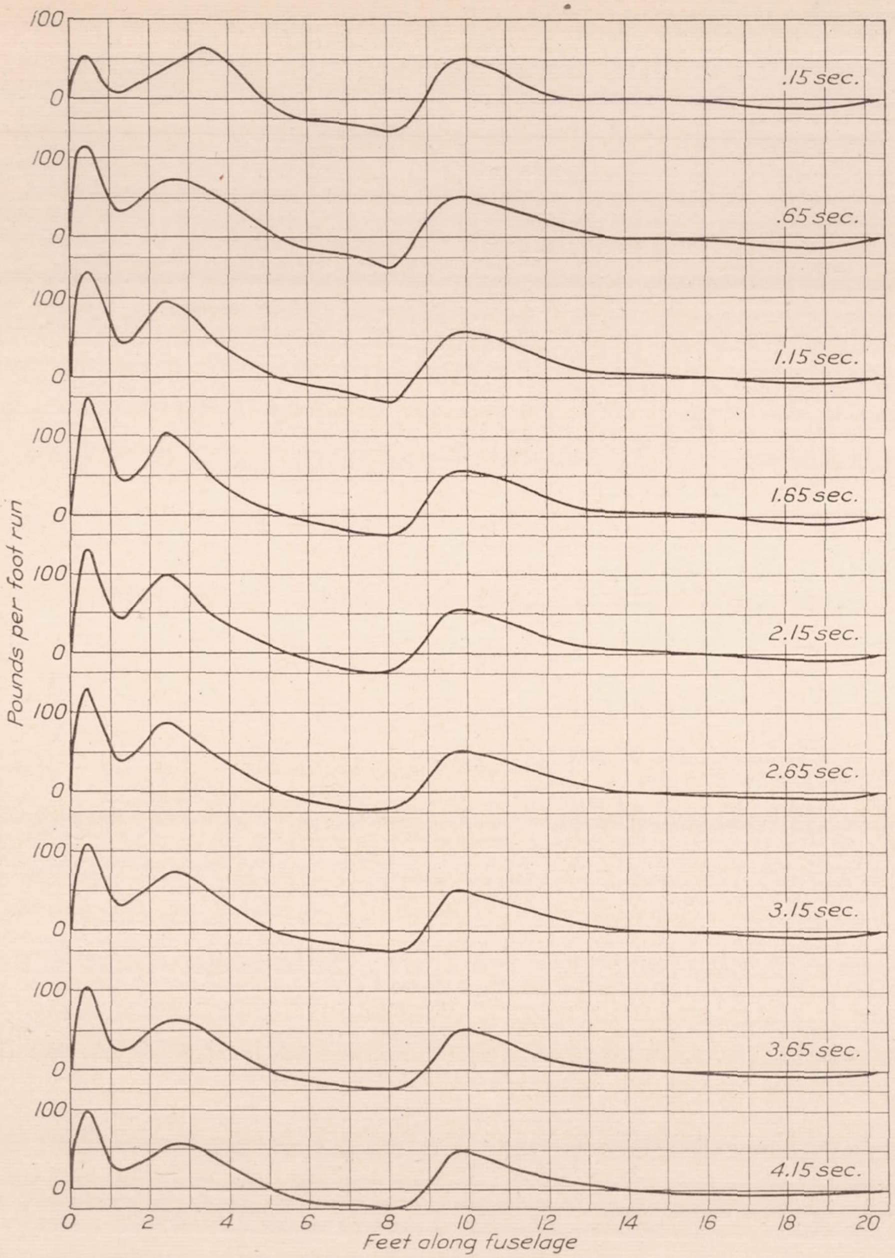

FIGURE 8.—Fuselage normal load curves. Mild pull-out of dive. Run No. 7, 1a

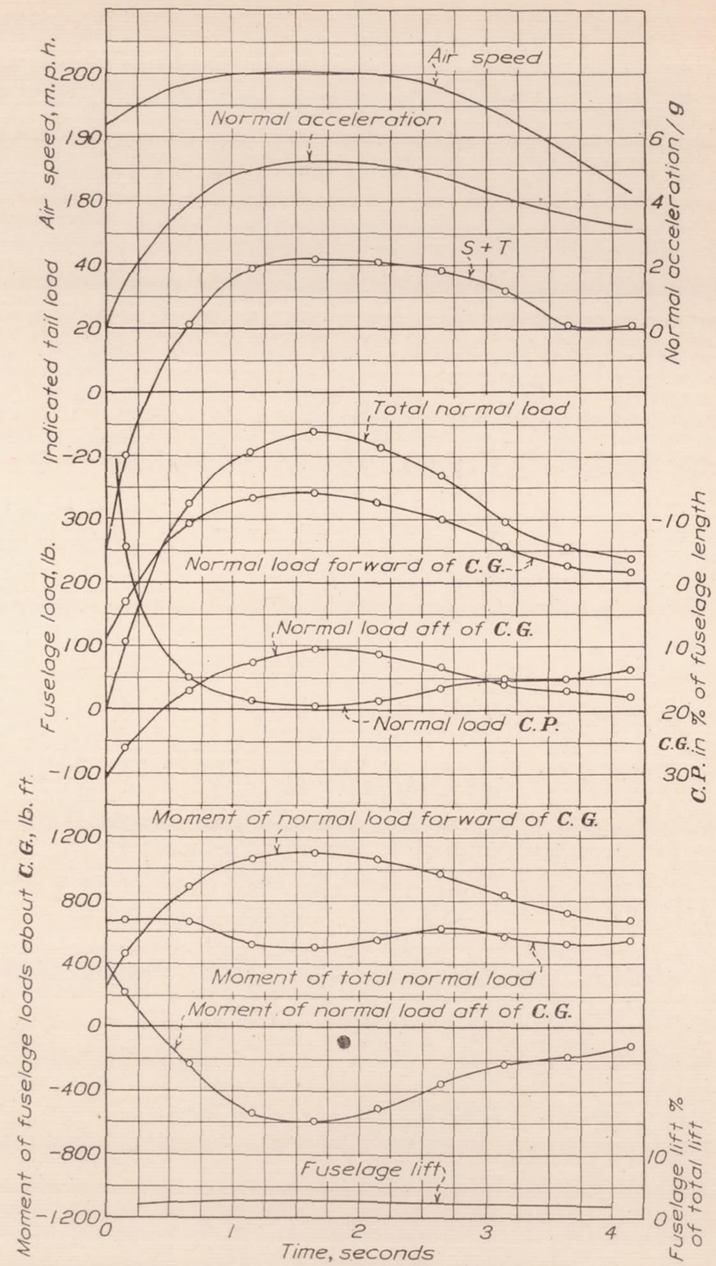

FIGURE 9.—History of a mild pull-out of dive. Run No. 7, 1a

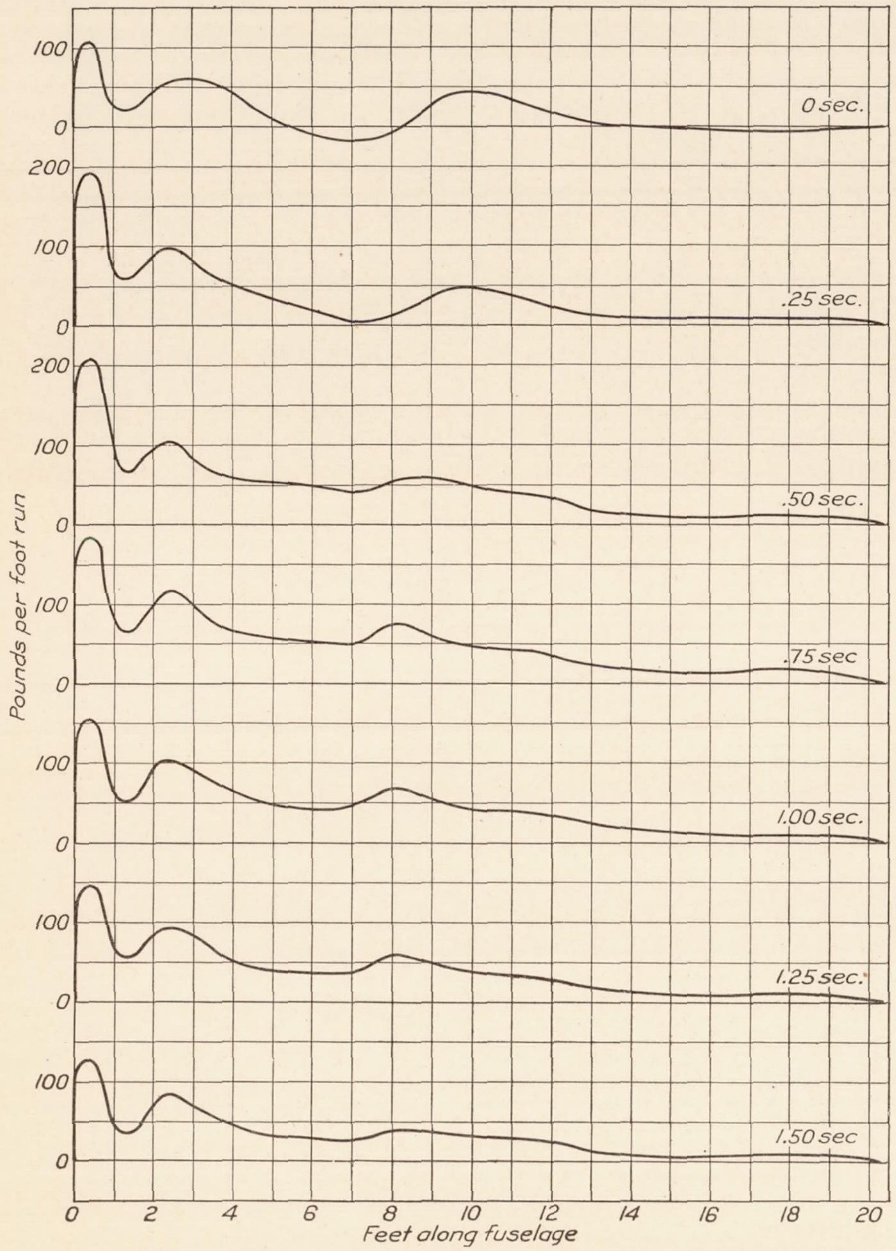

FIGURE 10.—Fuselage normal load curves. Abrupt power-on pull-up at 163 m. p. h. Run No. 9, 1b

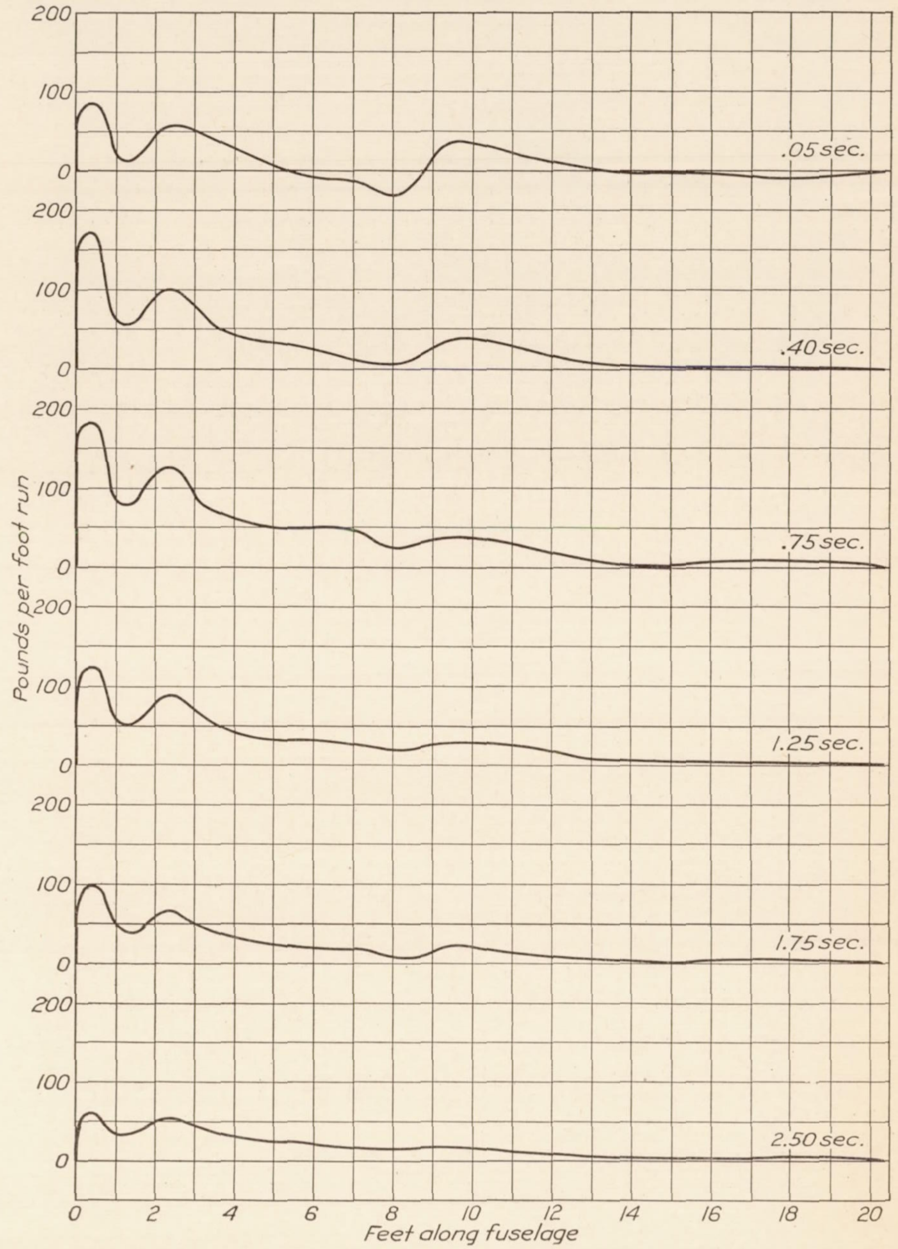

FIGURE 11.—Fuselage normal load curves. Abrupt power-off pull-up at 162 m. p. h. Run No. 9, 2b

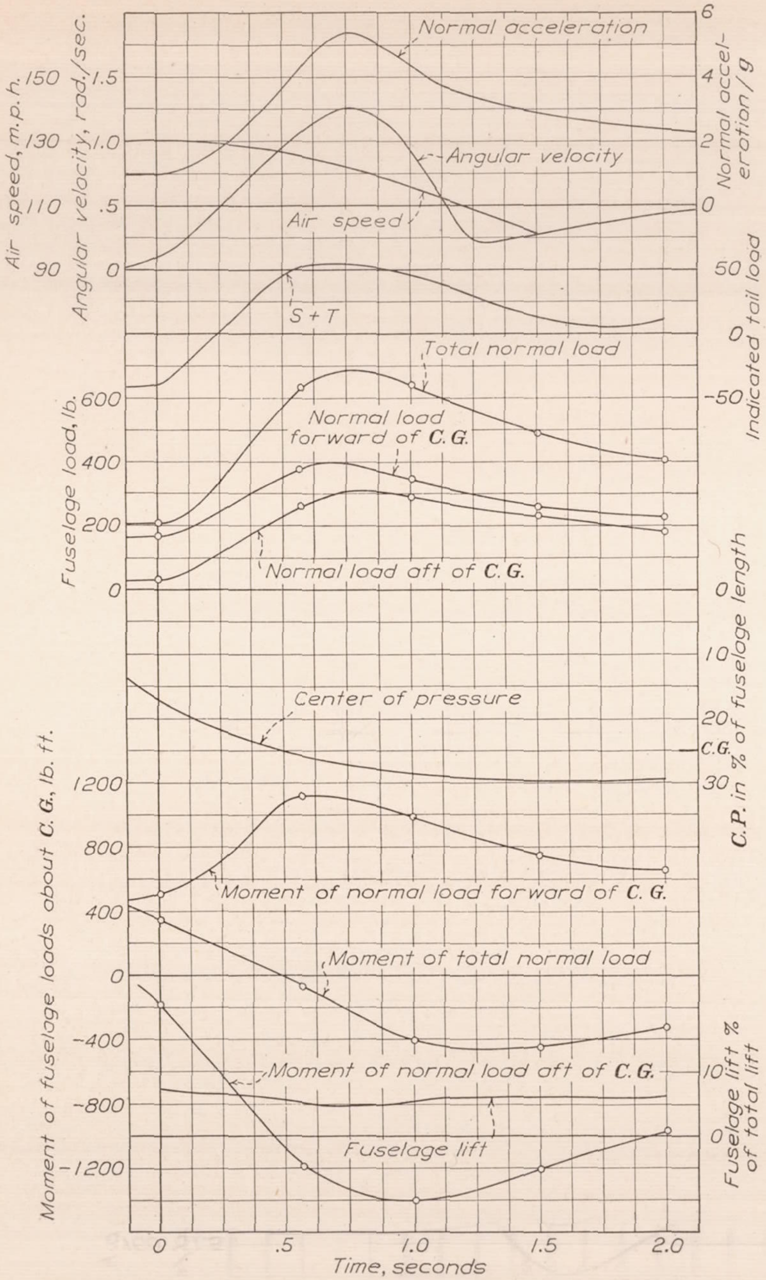

FIGURE 12.—History of an abrupt power-on pull-up at 130 m. p. h. Run No. 8, 2a

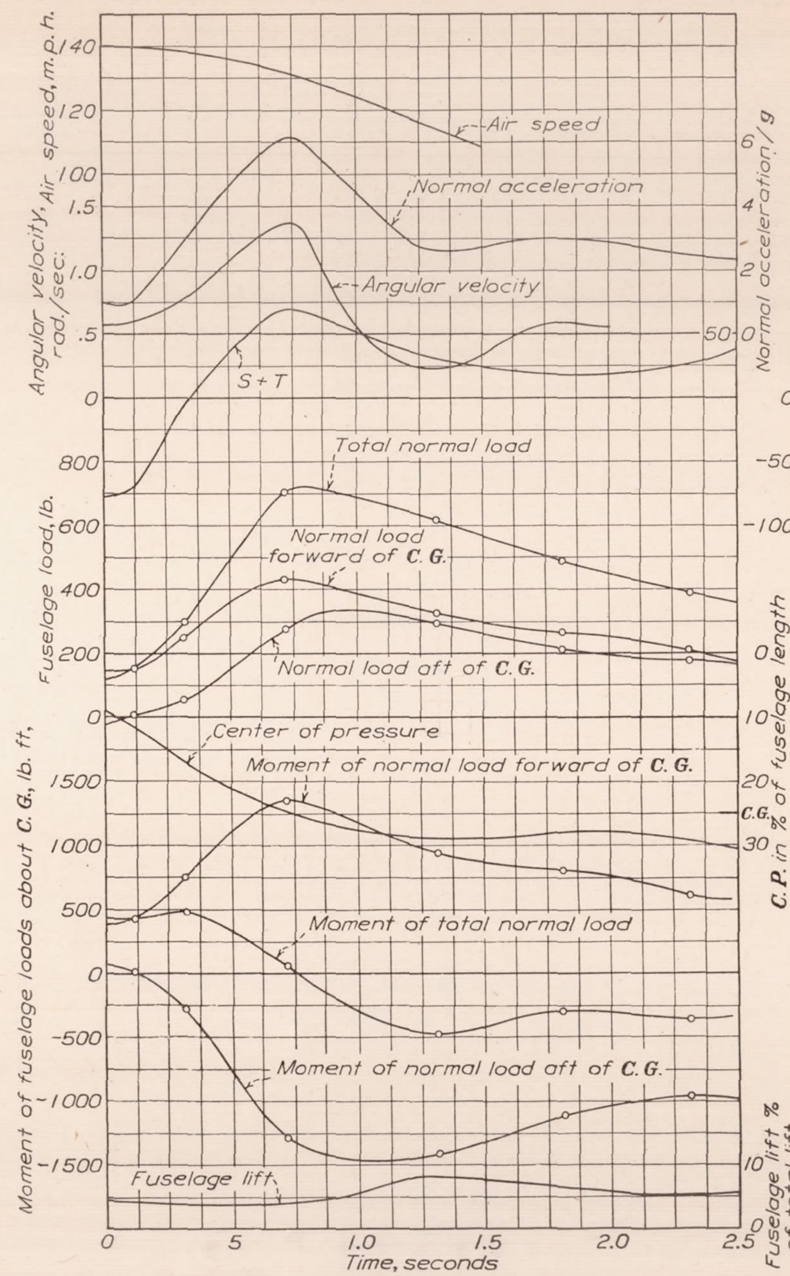

FIGURE 13.—History of an abrupt power-on pull-up at 140 m. p. h. Run No. 8, 2b

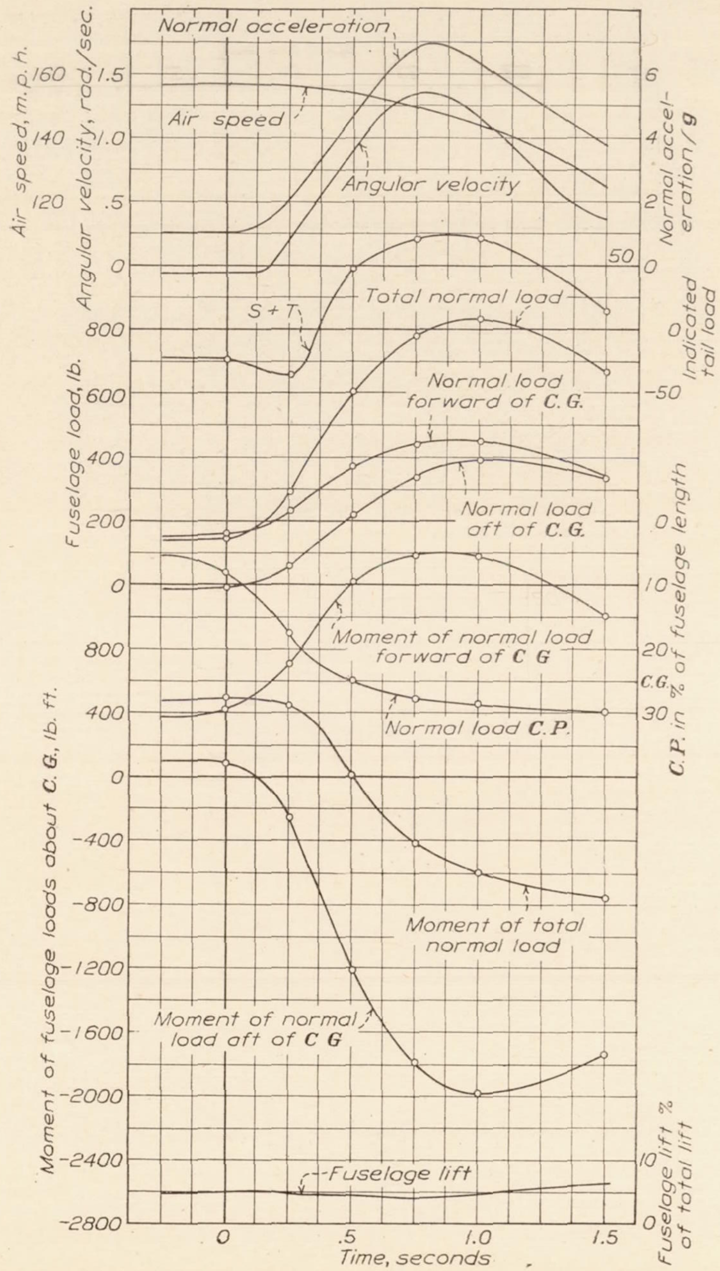

FIGURE 14.—History of an abrupt power-on pull-up at 156 m. p. h. Run No. 9, 1a

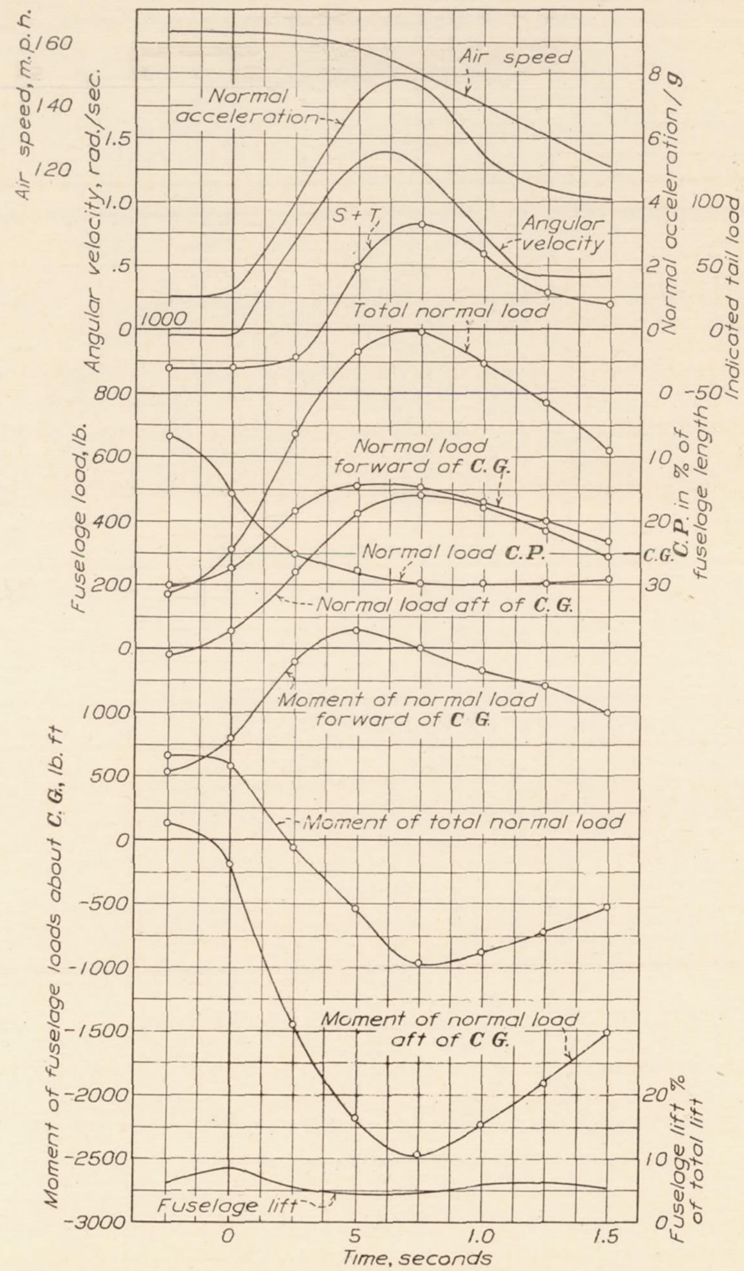

FIGURE 15.—History of an abrupt power-on pull-up at 163 m. p. h. Run No. 9, 1b

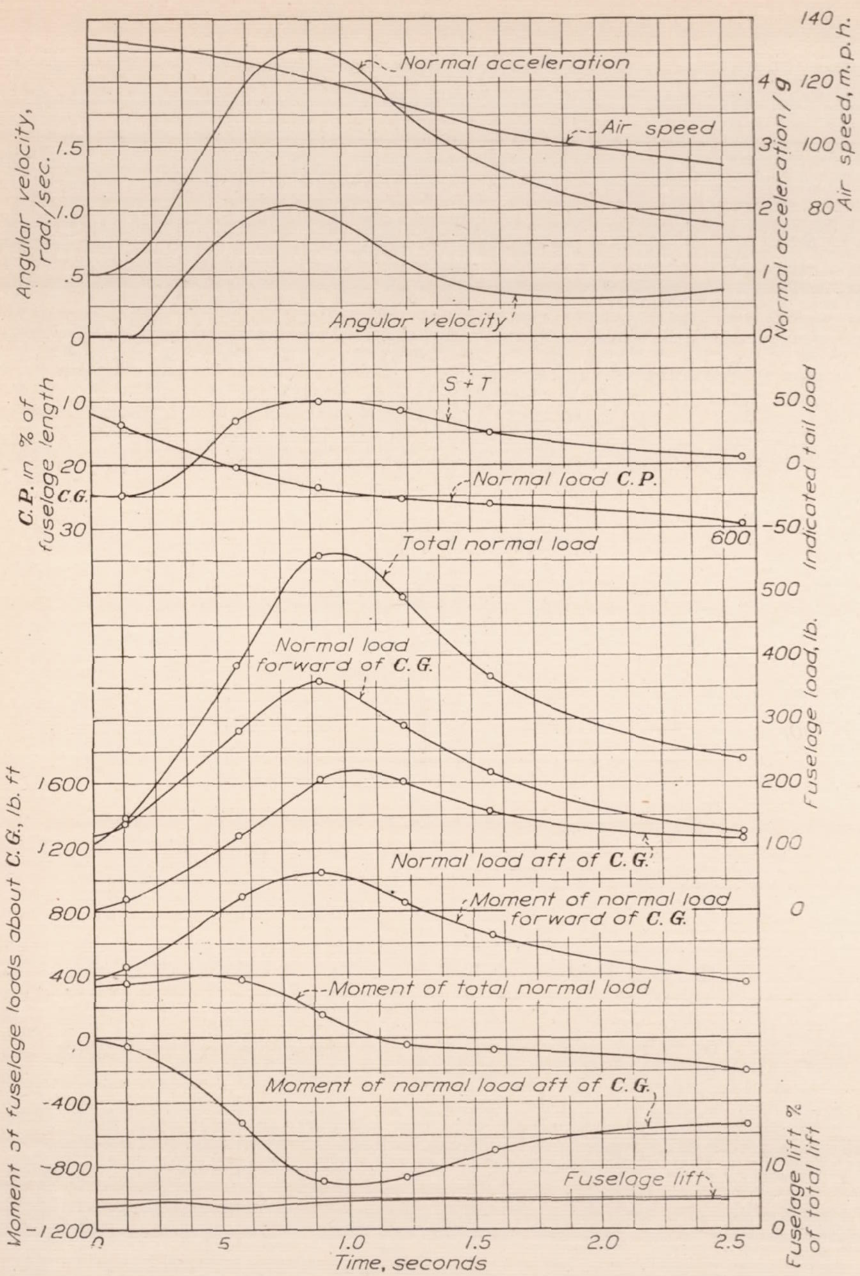

FIGURE 16.—History of an abrupt power-off pull-up at 133 m. p. h. Run No. 9, 2a

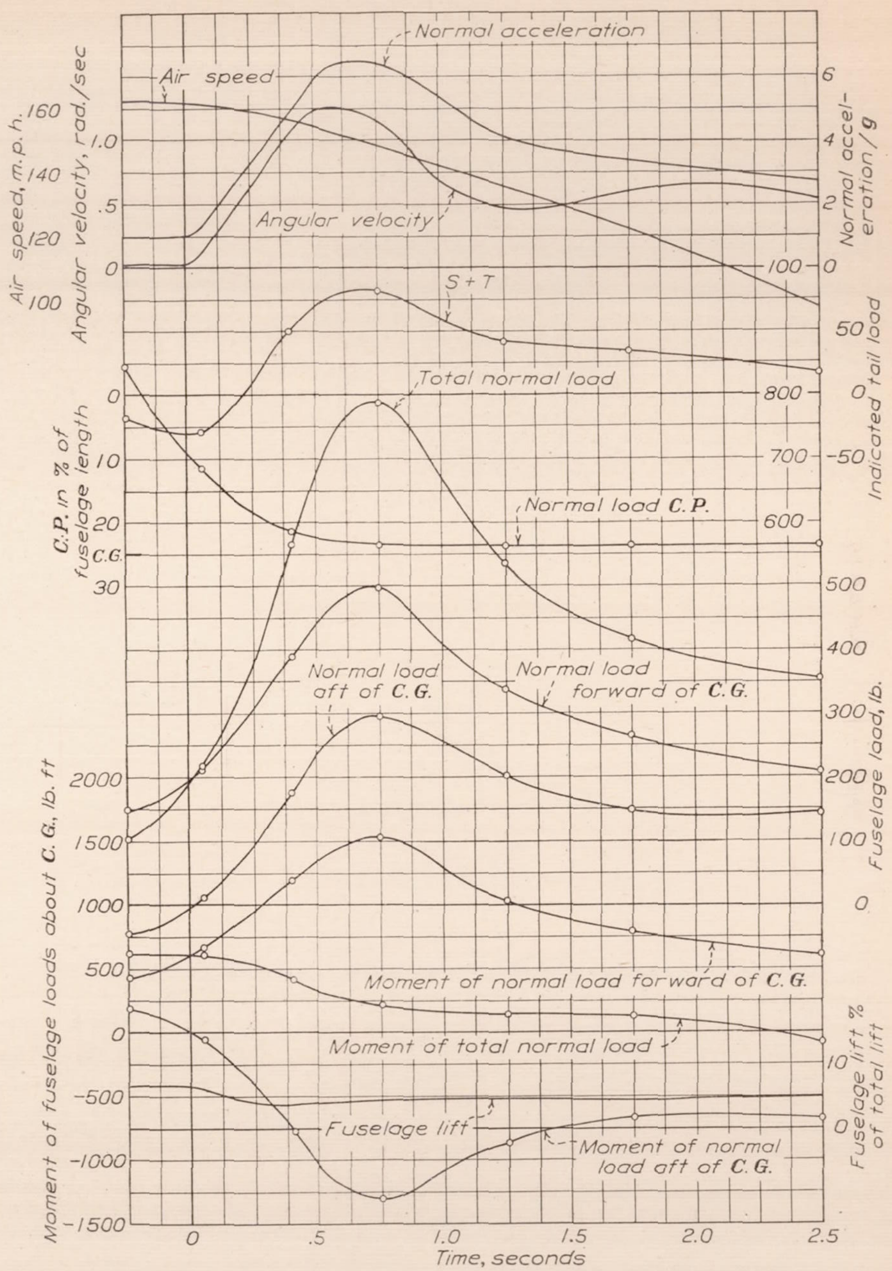

FIGURE 17.—History of an abrupt power-off pull-up at 162 m. p. h. Run No. 9, 2b

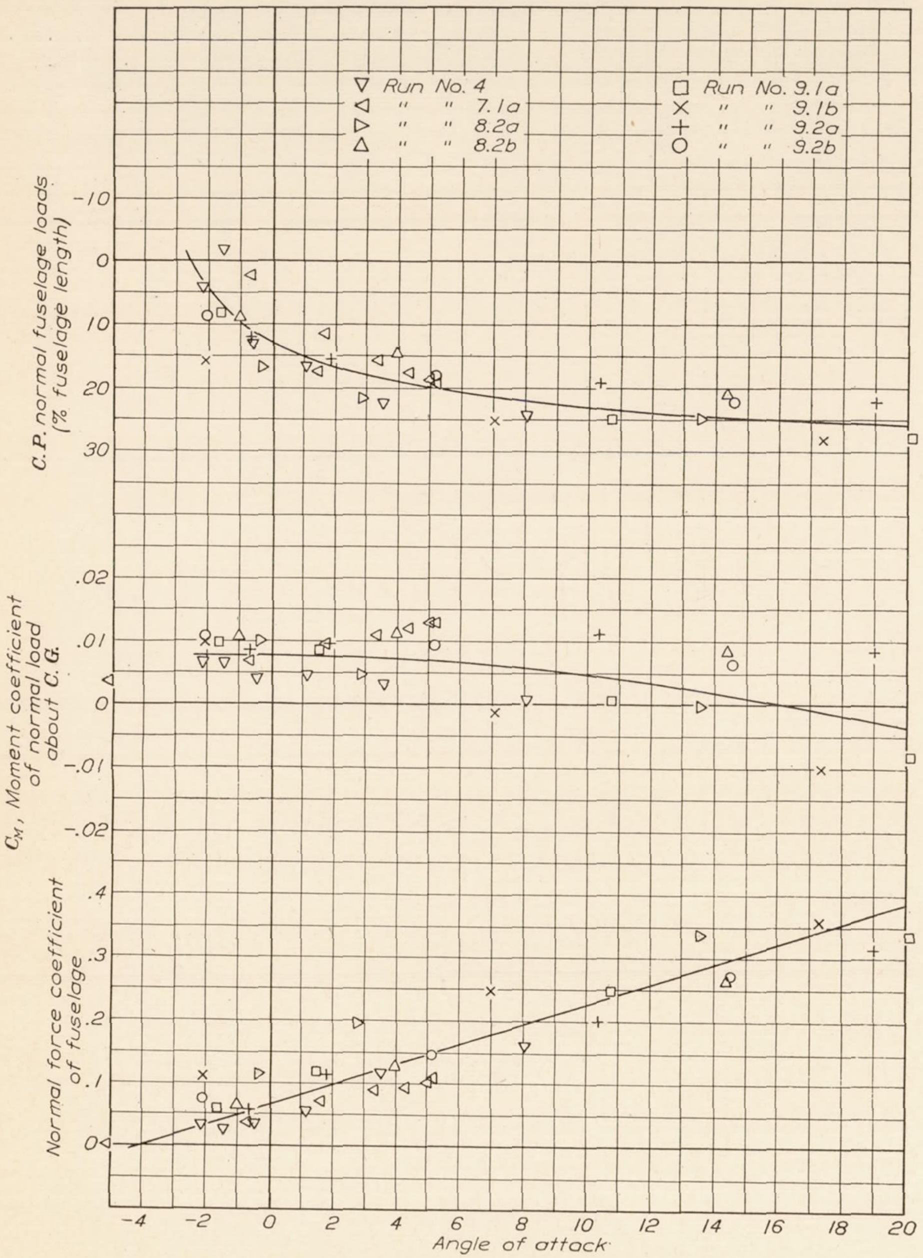

FIGURE 18.—PW-9 fuselage characteristics

$$\left(C_M = \frac{M_{CG}}{q \times A_f \times \text{fuselage length}} \right)$$

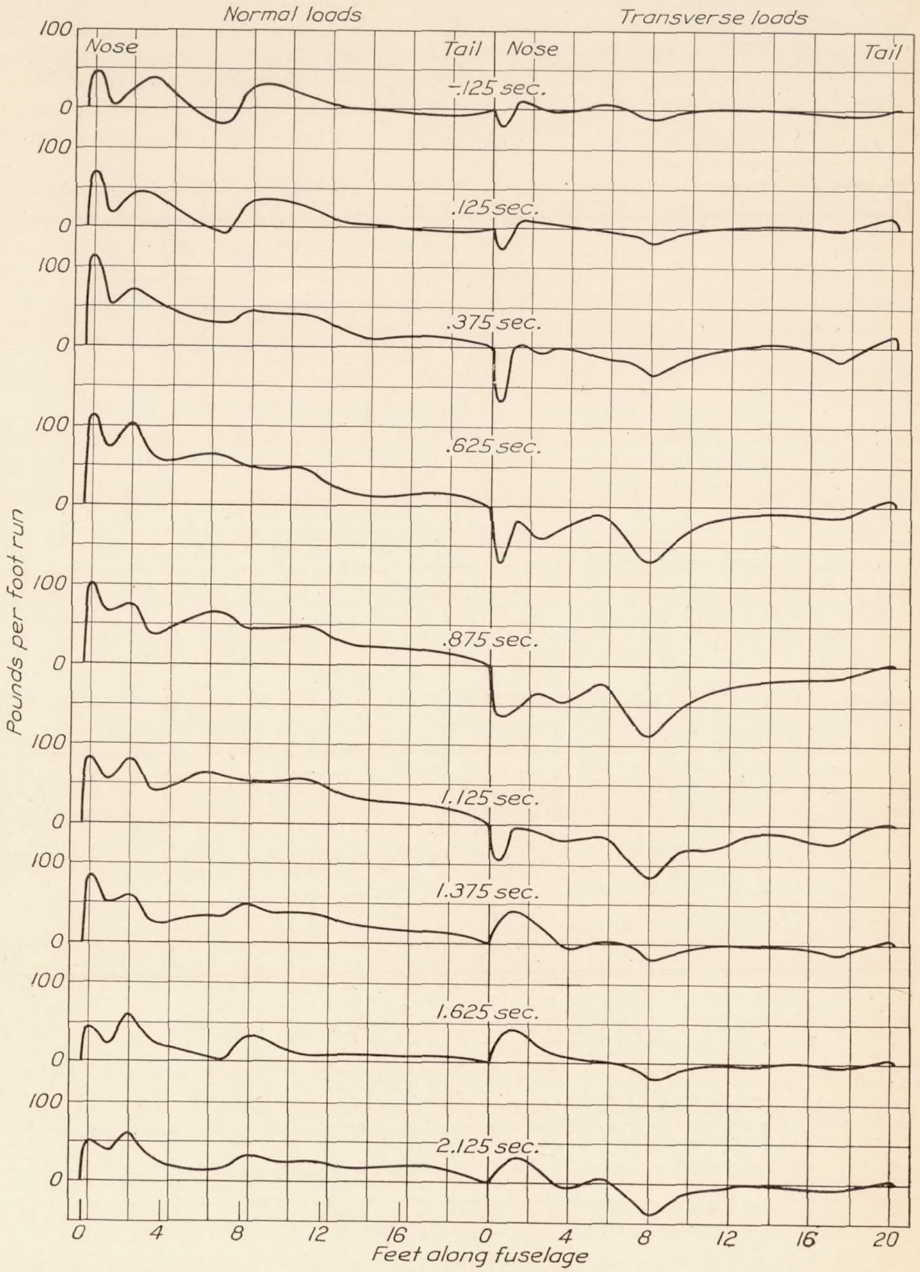

FIGURE 19.—Fuselage load curves in a right barrel roll. Run No. 3, 1a

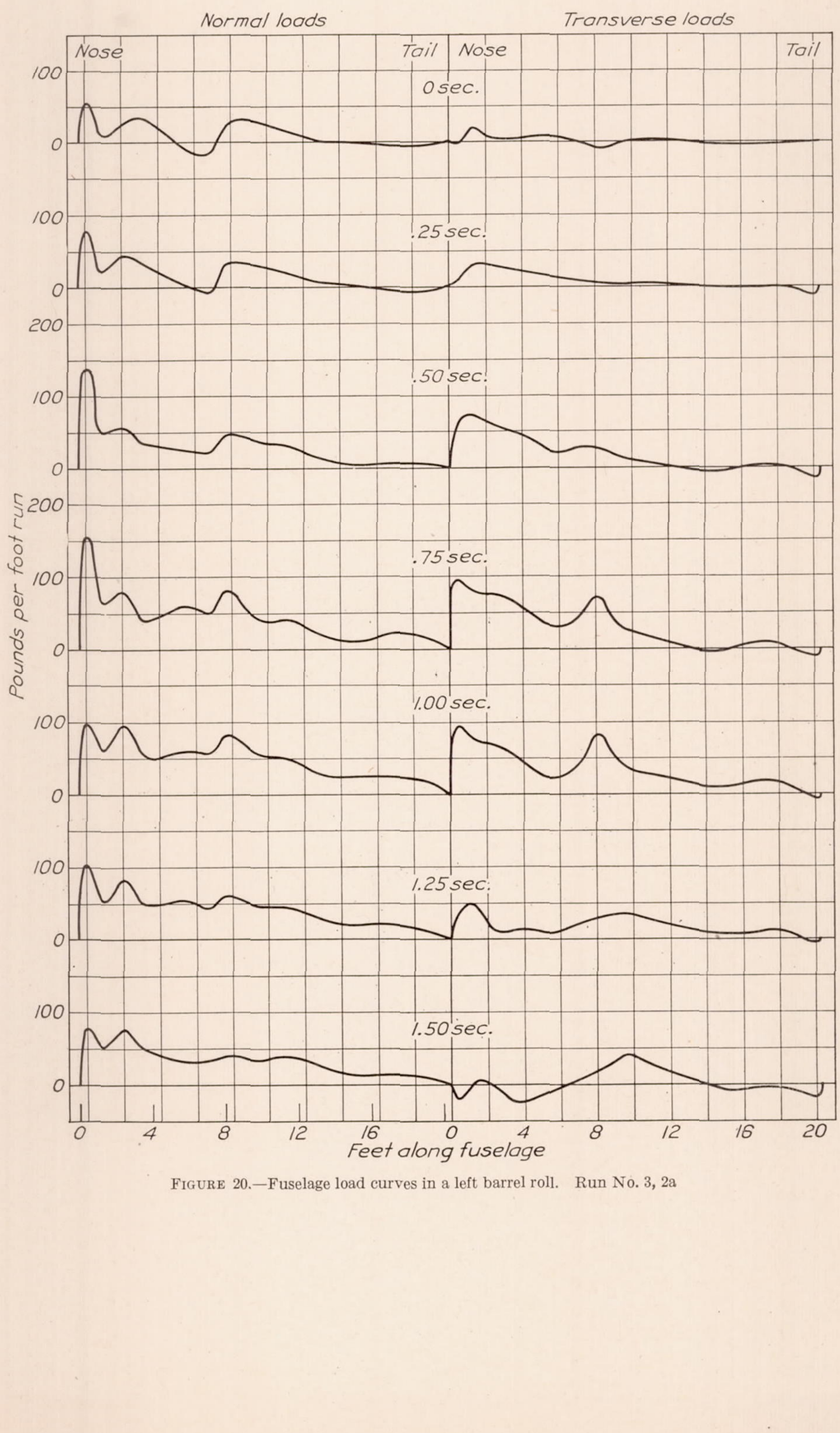

FIGURE 20.—Fuselage load curves in a left barrel roll. Run No. 3, 2a

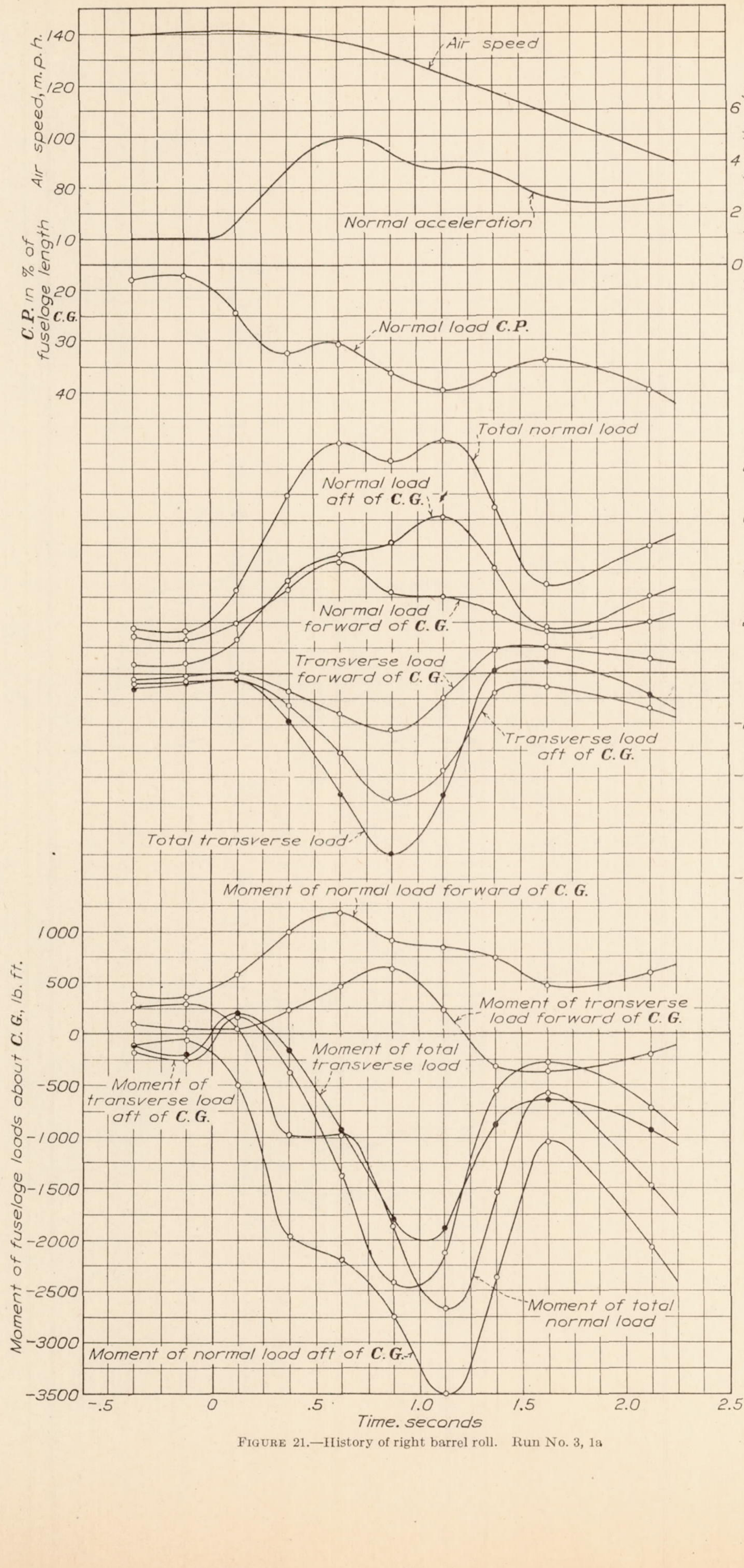

FIGURE 21.—History of right barrel roll. Run No. 3, 1a

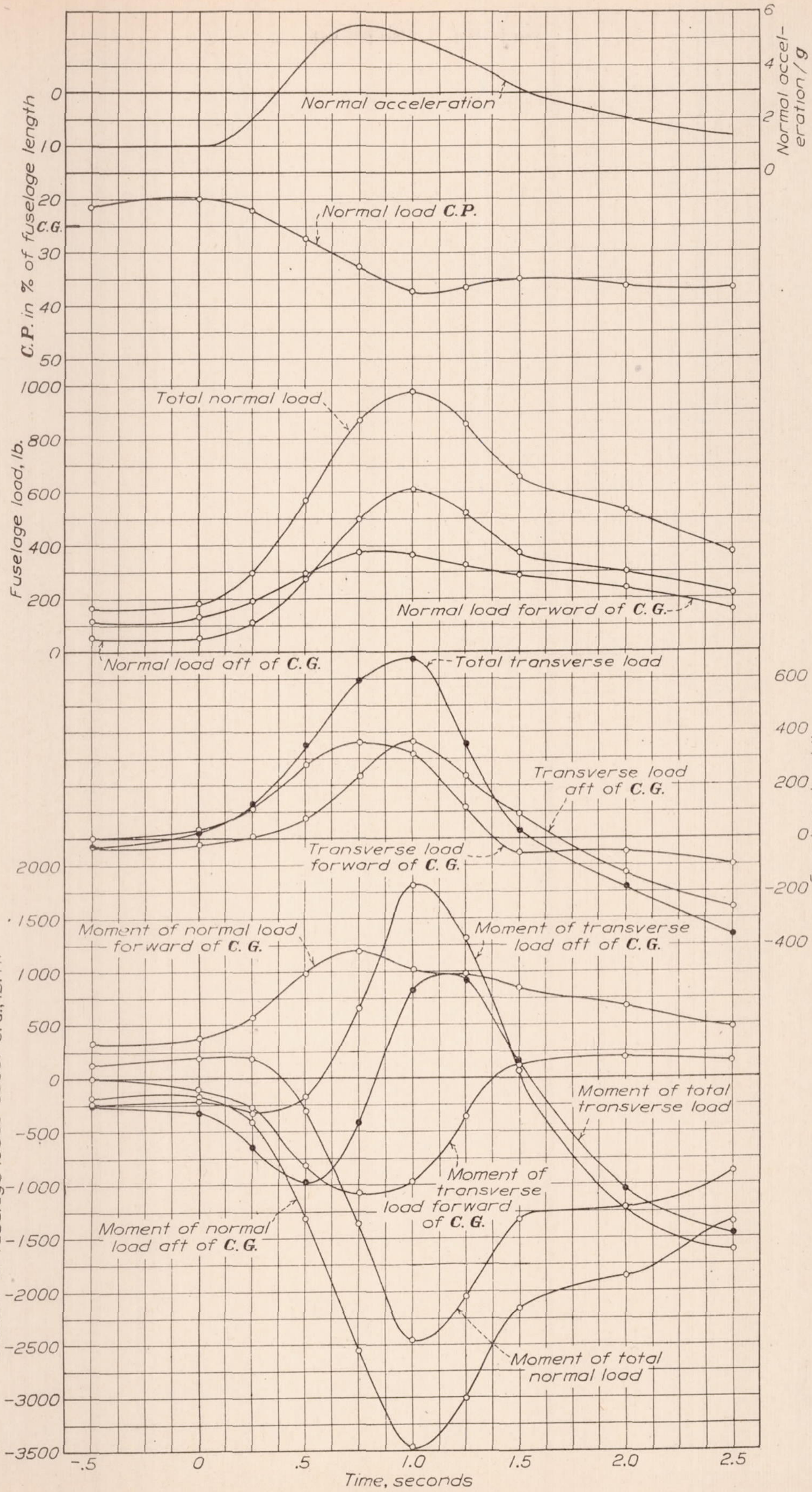

FIGURE 22.—History of left barrel roll. Run No. 3, 2a

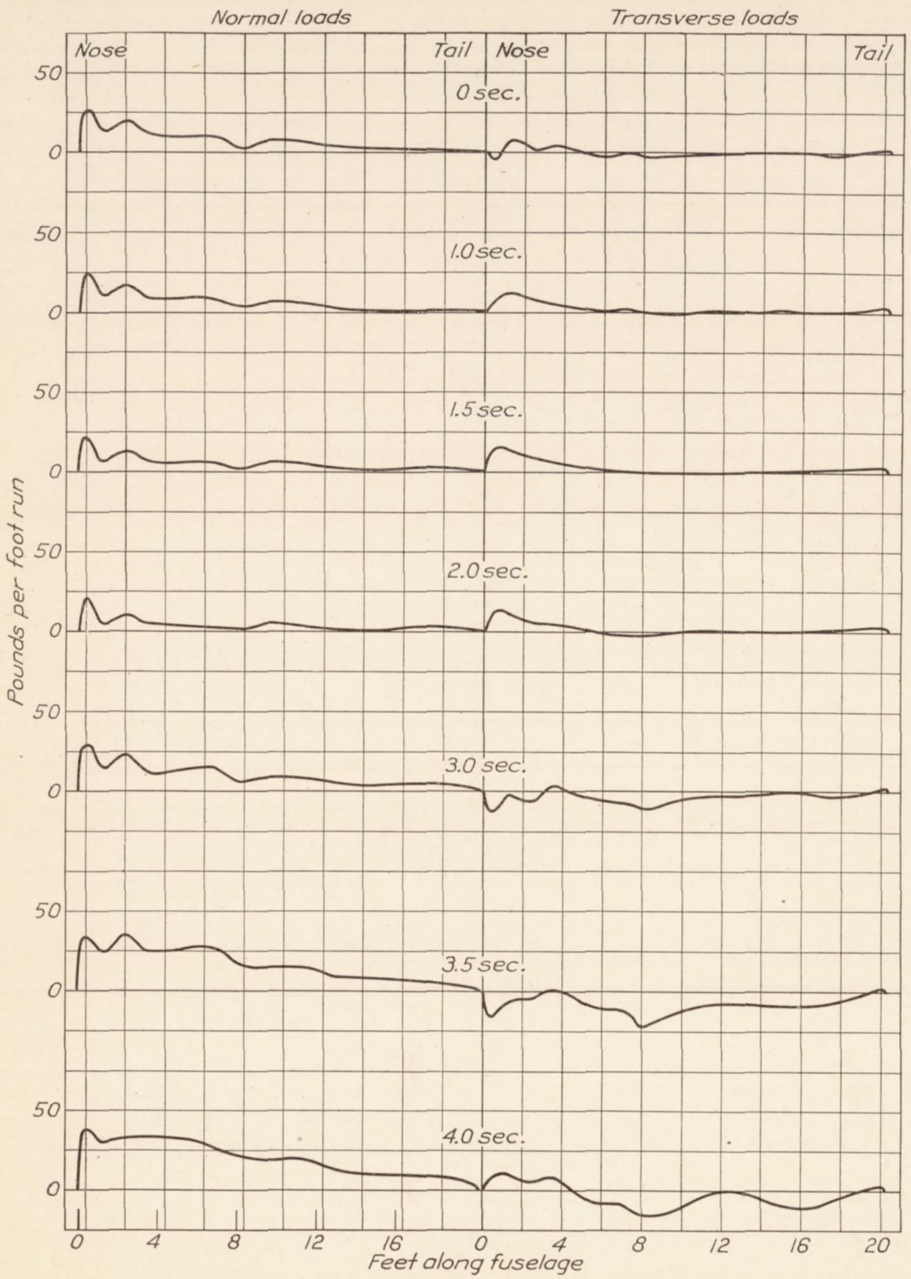

FIGURE 23a

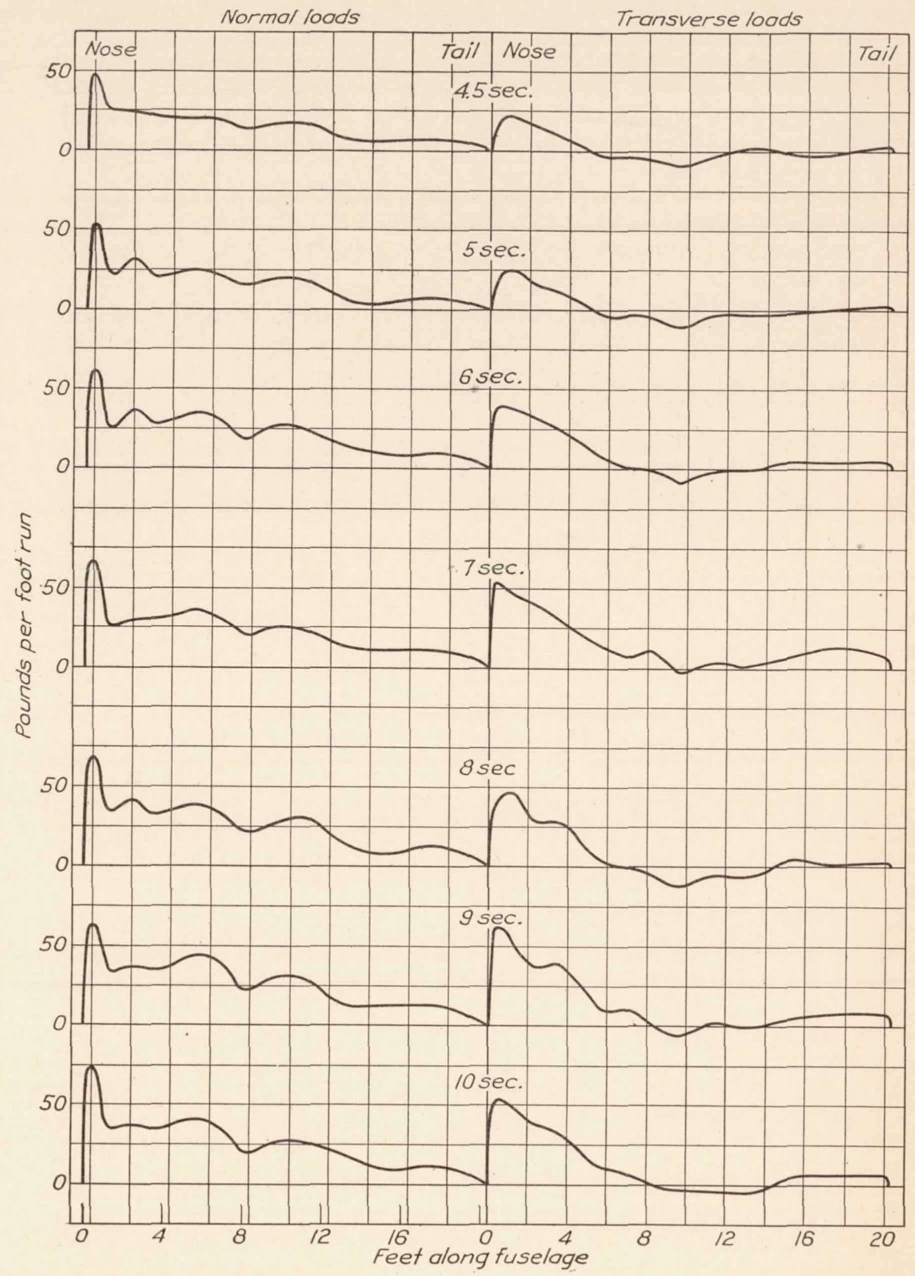

FIGURE 23b

Fuselage load curves in a right spin. Run No. 13, 2a

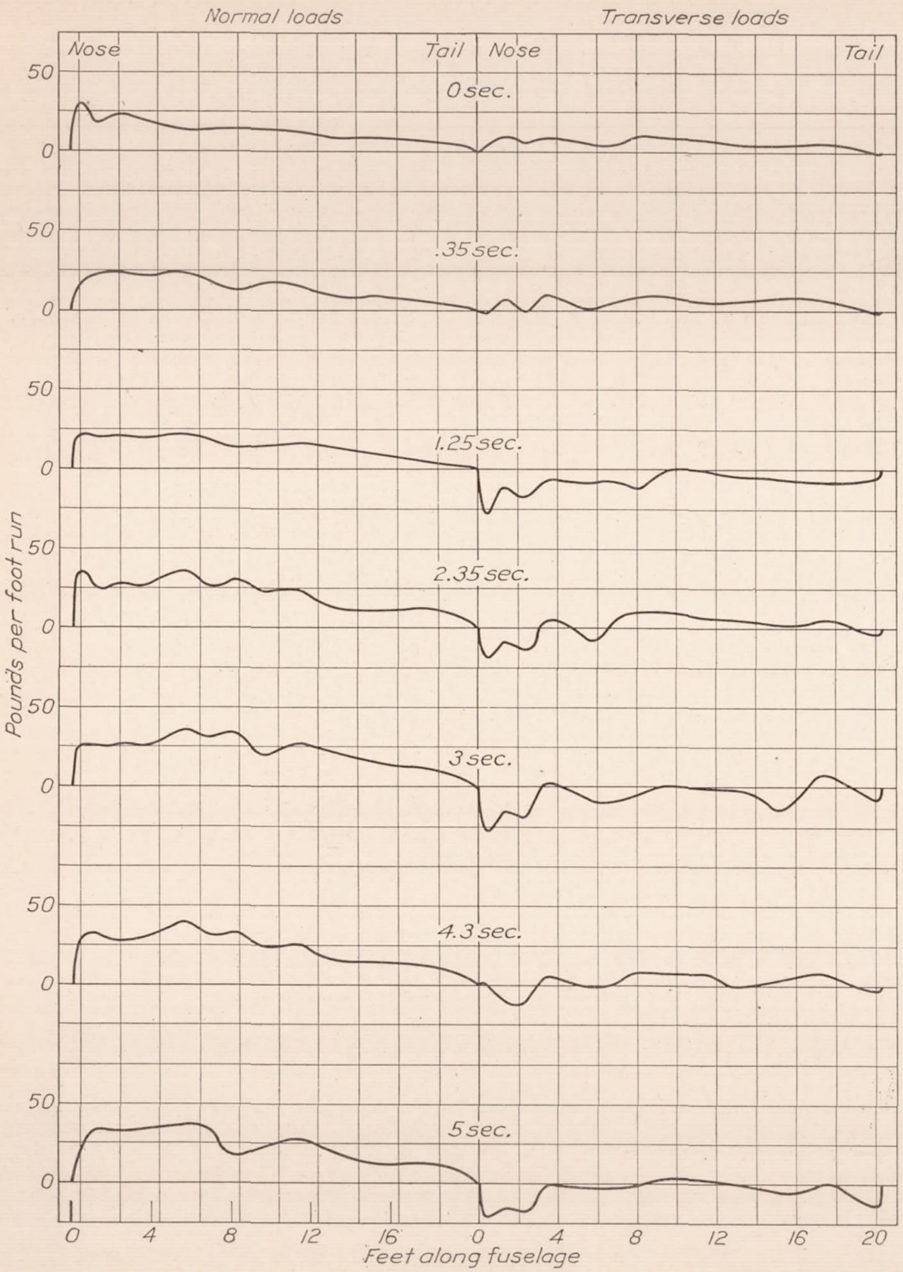

FIGURE 24a

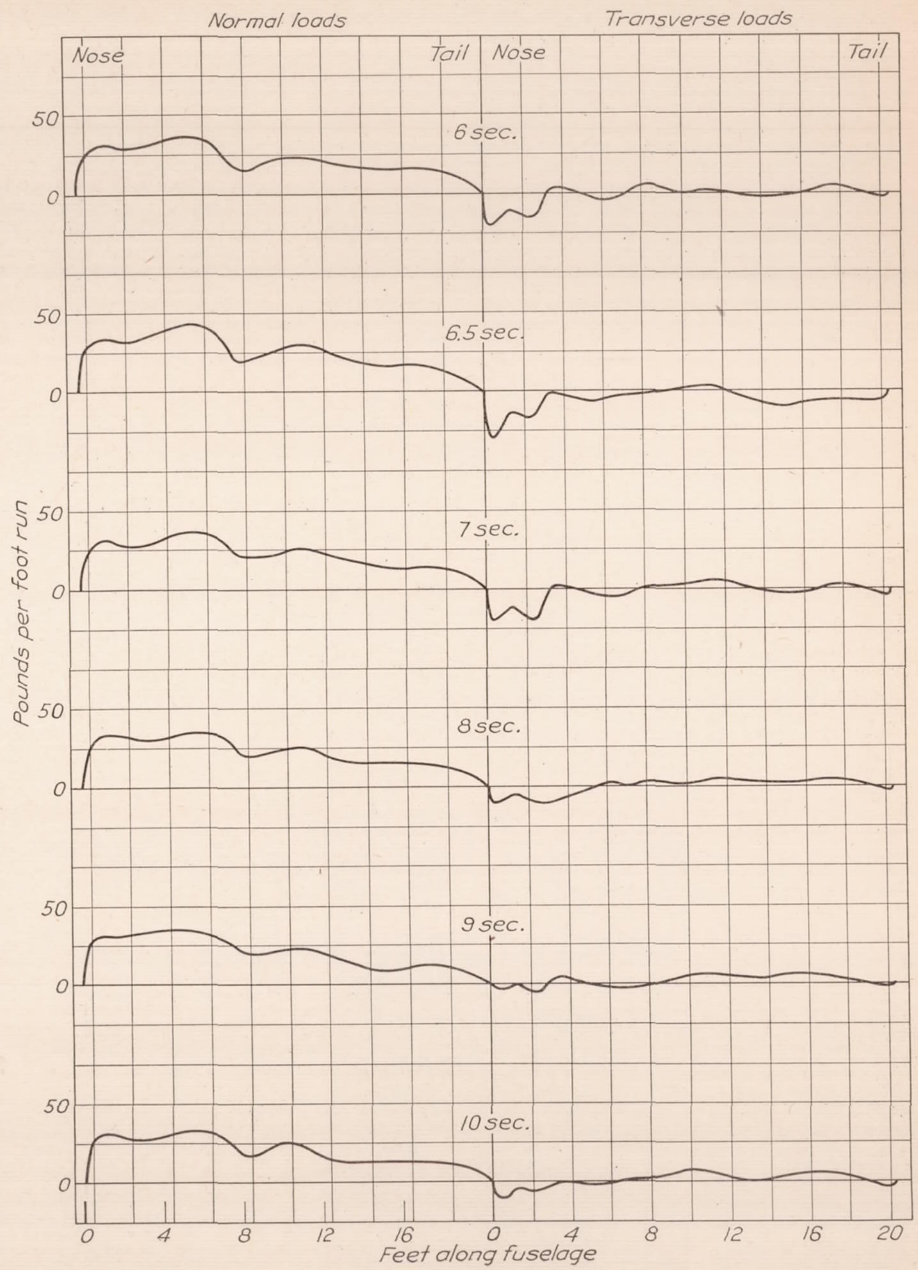

FIGURE 24b

Fuselage load curves in a left spin. Run No. 12, 2a

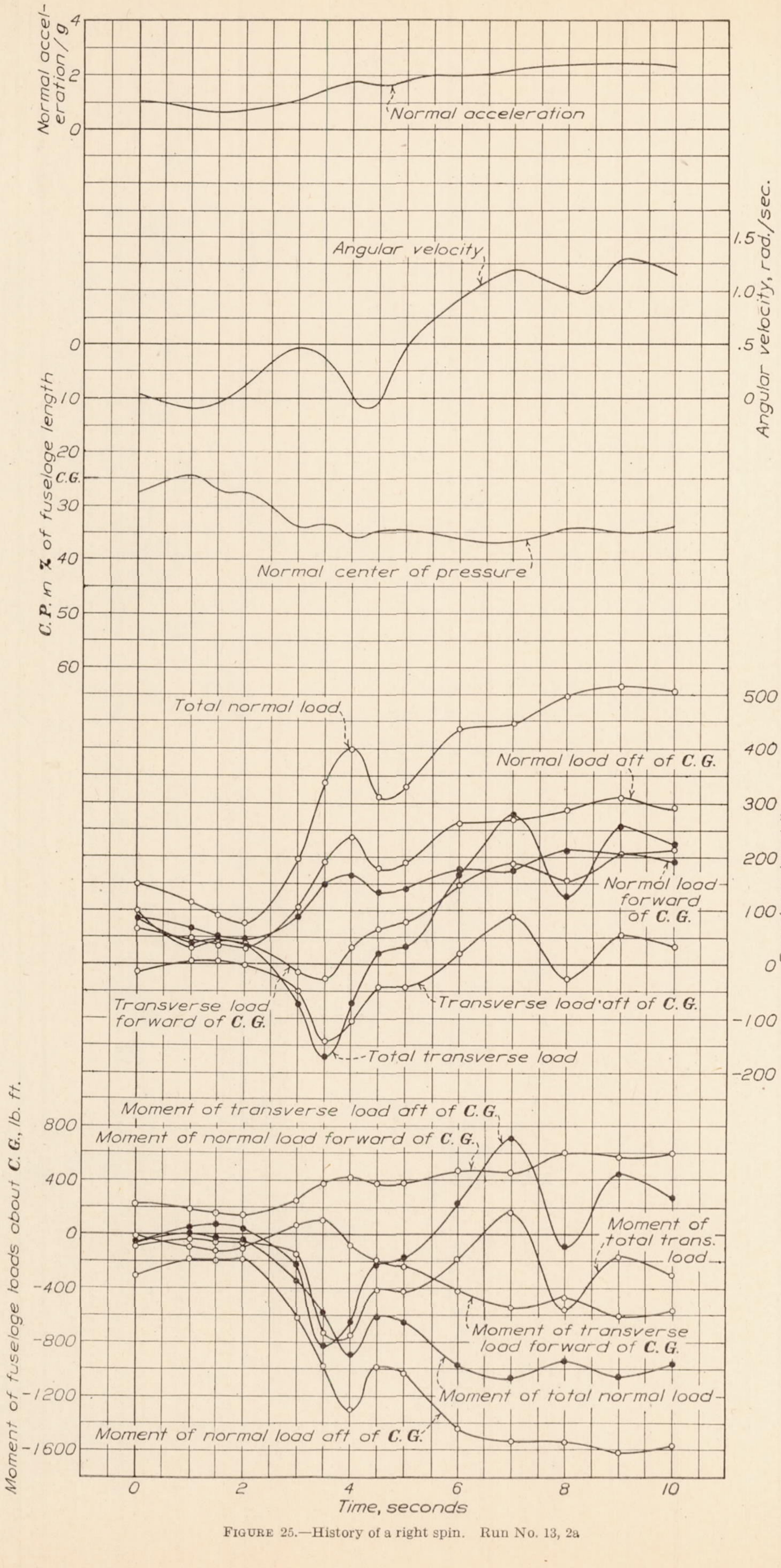

FIGURE 25.—History of a right spin. Run No. 13, 2a

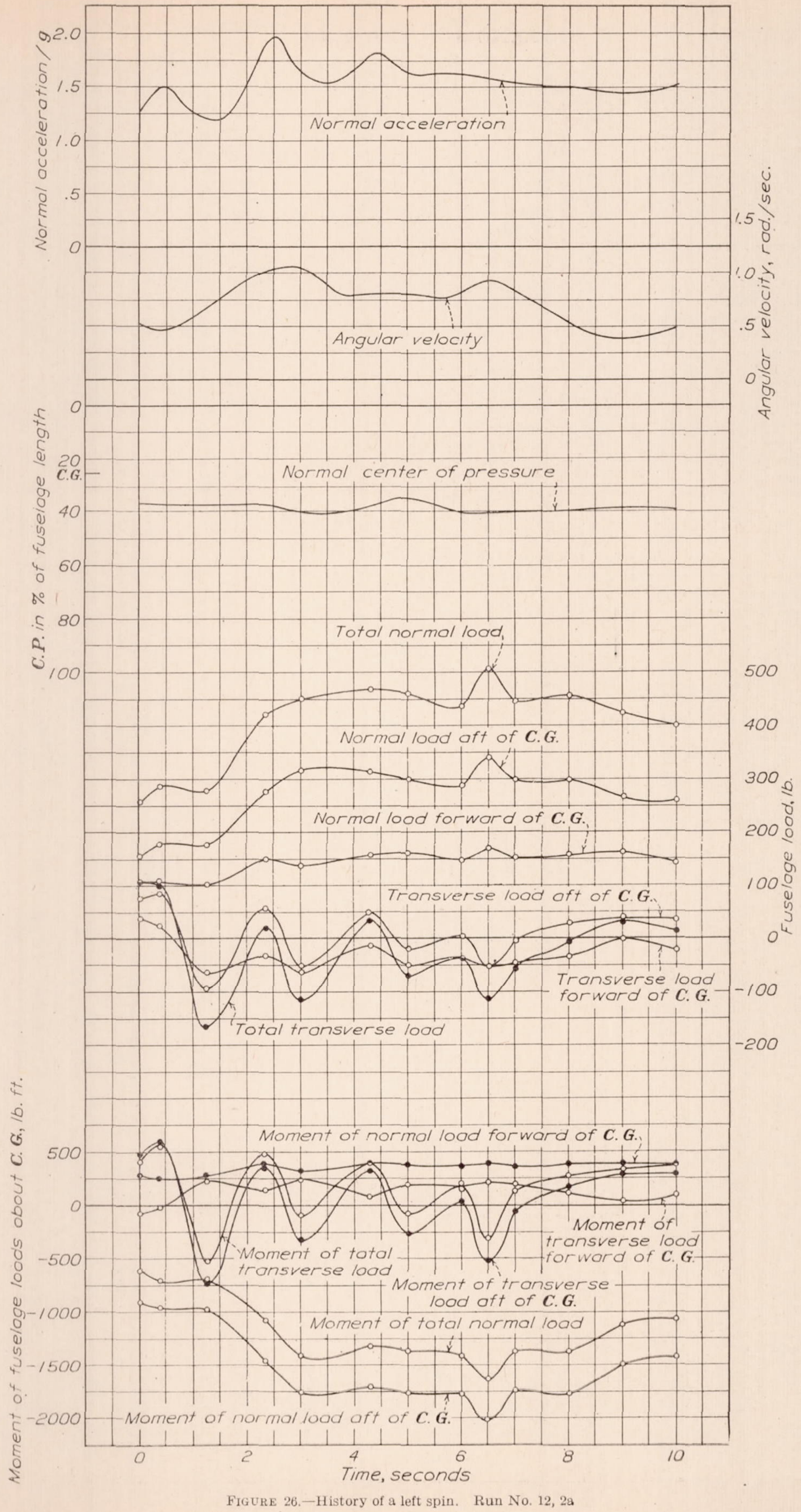

FIGURE 26.—History of a left spin. Run No. 12, 2a

TABLE I

CHARACTERISTICS OF PW-9 AIRPLANE

Span of upper wing	32 ft. 0 in.
Span of lower wing	22 ft. 5¾ in.
Fuselage length	20 ft. 5 in.
Plan area of fuselage	40.8 sq. ft.
Projected side area of fuselage	60.4 sq. ft.
Centroid of plan and side area of fuselage. Per cent of fuselage length	42.
Gap	52 in.
Stagger [1]	+2° 22′.
Dihedral (upper wing lower surface)	1° 6′.
Dihedral (lower wing lower surface)	1° 23′.
c. g. position:	
(Aft leading edge of root section, lower wing)	18¼ in.
(Above lower surface root section, lower wing)	23¾ in.
Distance from *c. g.* to center line of elevator hinge	14 ft. 11⅝ in.
Distance from *c. g.* to center line of rudder hinge	15 ft. 3⅝ in.
Area of upper wing	160.4 sq. ft.
Area of lower wing	80.8 sq. ft.
Total wing area	241.2 sq. ft.
Area of horizontal tail surfaces	29.84 sq. ft.
Area of vertical tail surfaces	13.75 sq. ft.
Weight of airplane during tests	2,900 lbs.
Rated horsepower at 2,000 r. p. m.	375.
Power loading	7.74 lb. per hp.
Wing loading	12 lb. per sq. ft.

[1] Stagger measured at a section parallel to the plane of symmetry, and passing through the centroid of the plan form of one lower wing between a line perpendicular to the chord of the upper wing and a line drawn from a point one-third chord length from the leading edge of the lower wing to a point similarly located on the upper wing.

TABLE II

COWLING PRESSURES

(Lbs. per sq. ft.)

Run No. 3, 1a Maneuver: Right roll Initial air speed 140 m. p. h.

Section		0.12 sec.				0.37 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−30.2	−8.8	−5.7	0	−51.0	−24.0	−18.2	−11.4
	2	−28.1	−10.4	−9.4	0	−53.5	−21.8	−15.1	−12.5
	3	−31.2	−7.3	0	−2.6	−62.4	−20.3	−6.8	−5.2
	4	−43.7	−8.8	0	−3.1	−65.5	−21.4	−10.4	−10.4
	5	−10.4	−10.4	−6.2	−8.3	−16.7	−15.6	−13.0	−18.2
	6	3.6	−6.2	−10.4	−10.4	−9.9	−15.6	−17.7	−19.3
	7	7.8	19.2	4.2	7.3	−6.8	40.0	−3.1	−12.0
	8	26.6	−10.4	12.0	9.9	30.2	−36.4	14.5	8.8
	9	−27.6	−12.5	6.2	11.4	−32.8	−7.8	2.6	4.2
	10	13.0	−13.5	13.0	21.8	9.9	−17.7	14.0	17.7
	11	12.5	−1.5	27.0	18.7	12.0	1.0	33.2	18.8
	12	15.1	2.6	5.2	8.3	27.6	3.1	8.3	8.8
	13	--------	--------	2.1	13.5	--------	--------	3.1	16.7
	14	--------	--------	5.2	0	--------	--------	2.6	−13.5
	15	--------	--------	−4.7	−9.4	--------	--------	−6.8	−19.8
	16	--------	--------	−5.7	−9.4	--------	--------	−5.7	−18.2

Section		0.62 sec.				0.87 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−69.6	−38.5	−32.8	−19.8	−61.3	--------	−28.6	−22.4
	2	−64.0	−31.2	−20.8	−30.2	−54.6	−29.2	--------	--------
	3	−73.8	−32.2	−31.2	−10.9	−62.4	−26.0	−24.4	−12.0
	4	−66.5	−27.0	−16.7	−20.8	−48.9	−27.6	−10.4	−20.8
	5	−20.8	−20.8	−17.7	−19.3	−21.8	−15.6	−8.3	−15.6
	6	−19.8	−20.8	−19.8	−24.0	−21.4	−19.8	−18.2	−20.3
	7	−28.6	60.3	−9.9	−21.4	−41.0	60.3	−13.0	−16.7
	8	26.6	−66.0	18.2	−7.3	22.4	−95.6	18.2	−18.8
	9	−40.0	9.9	−17.2	−13.0	−42.1	20.3	−24.4	−22.4
	10	17.7	−15.6	17.7	12.5	19.8	−10.4	13.5	0
	11	15.6	6.2	34.8	20.3	15.6	11.9	21.3	9.9
	12	36.4	11.4	12.5	10.4	32.8	20.8	12.5	7.8
	13	--------	--------	6.8	18.2	--------	--------	9.9	16.6
	14	--------	--------	5.2	−15.1	--------	--------	10.4	−6.8
	15	--------	--------	−4.2	−16.7	--------	--------	2.6	−5.7
	16	--------	--------	−1.0	−21.8	--------	--------	3.1	−9.3

TABLE II—Continued

COWLING PRESSURE—Continued

(Lbs. per sq. ft.)

Section		1.12 sec.				1.37 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−56.0	−26.0	−25.0	−22.4	−38.4	−23.9	−19.2	−19.7
	2	−46.3	−24.4	------	--------	−35.9	−25.0	−20.8	−5.2
	3	−39.5	−23.4	−23.9	−12.0	−33.8	−19.8	−18.7	−8.3
	4	−42.6	−23.9	−20.3	−18.2	−40.5	−19.2	−20.3	−13.0
	5	−10.4	−6.2	−4.2	−15.6	17.7	−1.6	−3.1	−19.8
	6	−18.2	−13.0	−14.5	−22.4	4.2	−3.6	−10.4	−21.3
	7	−28.6	52.4	−10.4	−15.6	7.8	25.5	−4.2	−10.4
	8	30.2	−71.0	21.3	−16.6	37.4	−26.0	20.3	−8.8
	9	−30.7	0	−16.1	−15.6	−17.2	−26.0	−5.2	−4.7
	10	3.6	−21.3	7.8	−2.6	−19.8	−24.4	9.3	2.6
	11	9.3	1.0	8.3	6.2	14.0	−10.9	12.5	3.1
	12	15.1	14.0	6.8	4.7	7.8	2.1	−5.2	−1.0
	13	--------	--------	2.1	8.3	--------	--------	−6.2	−3.6
	14	--------	--------	−1.6	−13.5	--------	--------	−9.3	−18.7
	15	--------	--------	−8.8	−14.0	--------	--------	−8.8	−16.6
	16	--------	--------	0	−14.0	--------	--------	−4.2	−14.0

Section		1.62 sec.				2.12 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−25.4	−17.7	−14.5	−16.6	−27.6	−17.7	−19.8	−16.6
	2	−26.5	−13.0	−20.8	0	−26.5	−23.4	--------	−4.2
	3	−33.8	−13.0	−10.4	−4.2	−36.4	−13.0	−16.1	−5.2
	4	−34.3	−10.9	−10.4	−7.8	−36.4	−15.6	−13.0	−10.4
	5	17.7	−1.0	−2.1	−15.1	10.4	0	−1.0	−15.6
	6	8.8	3.6	−4.2	−12.5	1.6	−1.0	−8.3	−15.6
	7	15.6	8.3	.5	−4.2	8.8	17.2	−2.1	−10.4
	8	27.0	0	15.6	5.2	26.5	−12.5	12.0	.5
	9	−7.8	−34.3	4.7	6.8	−10.4	−21.8	1.0	2.1
	10	−18.2	−18.7	12.0	9.9	−14.6	−16.6	11.4	8.3
	11	7.8	−6.8	17.7	7.3	9.3	−7.3	15.1	8.3
	12	4.2	−1.6	−4.2	−2.1	6.2	1.0	−3.6	2.1
	13	--------	--------	−5.2	0	--------	--------	−4.2	0
	14	--------	--------	−5.2	−13.5	--------	--------	−5.2	−15.1
	15	--------	--------	−6.2	−10.4	--------	--------	−6.2	−10.4
	16	--------	--------	−4.2	−5.7	--------	--------	−5.2	−5.7

Run No. 3, 2a Maneuver: Left roll Initial air speed 140 m. p. h.

Section		0 sec.				0.25 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−23.0	−3.0	2.0	−.5	−32.0	−11.5	−6.0	−1.5
	2	−20.0	−4.5	−2.5	1.0	−30.0	−11.3	−6.5	1.0
	3	−22.0	−3.0	3.0	0	−30.0	−10.5	−1.0	0
	4	−26.0	−3.5	4.5	0	−41.0	−9.1	0	−.5
	5	−14.0	−2.5	−4.5	−7.0	−9.0	−2.0	−4.5	−12.5
	6	11.0	−1.0	−4.0	−5.0	12.0	−1.0	−4.5	−8.5
	7	16.0	8.5	5.5	10.5	21.0	8.0	6.0	8.5
	8	27.0	0	9.6	3.3	32.0	1.5	14.0	11.0
	9	−25.0	−11.0	3.5	10.5	−25.0	−22.0	6.5	11.0
	10	13.0	−11.0	12.0	22.5	7.0	−16.0	14.5	22.0
	11	9.0	−4.5	21.0	17.0	5.0	−7.5	22.0	16.0
	12	5.0	.5	2.5	8.0	3.0	−2.0	3.5	6.0
	13	--------	--------	1.5	11.0	--------	--------	0	10.0
	14	--------	--------	5.5	5.5	--------	--------	−1.0	−7.8
	15	--------	--------	−1.0	−3.5	--------	--------	−7.0	−11.5
	16	--------	--------	−4.5	−8.5	--------	--------	−12.5	−15.5

Section		0.50 sec.				0.75 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−63.0	−26.0	−18.0	−5.5	−62.0	--------	−27.0	−14.0
	2	−61.0	−23.0	−11.5	−.5	−62.0	--------	--------	−12.3
	3	−57.0	−19.5	−7.5	−1.5	−68.0	--------	−19.0	−7.0
	4	−58.0	−18.5	−7.5	−2.0	−66.0	−27.5	−22.0	−8.5
	5	10.0	−.5	−4.5	−19.0	29.0	6.0	−4.5	−22.7
	6	13.0	1.0	−7.0	−14.0	21.0	6.5	−8.5	−17.0
	7	26.0	5.0	7.5	5.2	31.0	−1.5	7.5	1.0
	8	38.0	6.0	21.0	16.0	41.0	14.5	28.5	15.5
	9	−17.0	−53.0	10.5	12.5	−3.0	--------	12.0	13.5
	10	−18.0	−24.5	16.0	21.5	−42.0	−29.6	18.0	19.3
	11	−6.0	−15.0	23.0	13.5	−19.0	−22.5	27.8	9.5
	12	−3.0	−9.0	−7.0	−4.0	−13.0	−12.5	−24.5	−14.5
	13	--------	--------	−4.5	2.5	--------	--------	−10.0	−11.6
	14	--------	--------	−10.3	−31.3	--------	--------	−17.5	−40.5
	15	--------	--------	−16.5	−17.0	--------	--------	−19.5	−20.0
	16	--------	--------	−17.2	−21.3	--------	--------	−18.5	−21.3

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Section		1.00 sec.				1.25 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−48.0	−34.0	−33.0	−27.5	−38.0	−31.0	−30.0	−22.5
	2	−44.0	−30.0	−28.0	−22.0	−36.0	−28.0	−25.0	−21.5
	3	−58.0	−26.0	−25.0	−11.0	−45.0	−21.0	−19.0	−12.6
	4	−66.0	−58.0	−27.0	−13.0	−56.0	−19.0	−27.5	−14.0
	5	33.0	6.0	−7.0	−23.0	16.0	0	−9.0	−20.6
	6	14.0	7.0	−10.0	−18.5	1.0	0	−11.5	−19.0
	7	29.0	−2.5	3.5	−5.0	12.0	21.2	−3.0	−9.5
	8	40.0	14.0	31.5	7.5	35.0	−18.5	22.5	−2.0
	9	−.5	−60.0	7.6	12.0	−16.0	−40.5	−1.5	2.5
	10	−41.0	−34.5	18.0	14.0	−23.0	−26.5	16.0	7.0
	11	−21.0	−22.5	26.0	7.0	−16.0	−4.5	23.5	6.0
	12	−7.0	−3.0	−22.2	−17.0	11.0	3.5	−5.5	−2.5
	13	--------	--------	−14.0	−15.5	--------	--------	−5.5	−5.3
	14	--------	--------	−18.0	−32.2	--------	--------	−9.0	−21.0
	15	--------	--------	−16.5	−20.0	--------	--------	−9.0	−17.5
	16	--------	--------	−15.5	−19.5	--------	--------	−6.3	−16.0

Section		1.50 sec.				2.00 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−37.0	−28.0	−29.0	−21.5	−35.0	−32.4	--------	--------
	2	−38.0	−25.5	−25.0	−16.0	−35.0	−27.3	--------	−13.5
	3	−39.0	−18.0	−17.5	−13.5	−30.0	−13.5	−16.0	−11.5
	4	−36.0	−26.7	−16.5	−13.5	−26.0	−16.0	−9.5	−10.5
	5	−6.0	−3.8	−9.0	−16.0	−14.0	−6.5	−8.0	−11.5
	6	−10.0	−8.0	−12.0	−18.5	−17.0	−10.5	−11.0	−15.5
	7	−7.0	29.0	−6.5	−12.5	−14.0	32.0	−7.0	−14.0
	8	28.0	−39.5	17.0	−2.5	20.0	−47.0	9.0	−2.0
	9	−32.0	−3.0	−6.0	−1.0	−33.0	0.5	−7.0	−4.0
	10	3.0	−18.5	12.0	9.0	10.0	−12.5	7.0	4.0
	11	2.0	1.0	19.0	8.0	9.0	4.2	12.5	9.0
	12	18.5	6.5	4.0	3.5	19.8	10.5	4.5	3.0
	13	--------	--------	−1.5	2.0	--------	--------	1.0	4.0
	14	--------	--------	−1.0	15.0	--------	--------	3.5	−7.2
	15	--------	--------	−2.5	−15.0	--------	--------	−1.5	−9.0
	16	--------	--------	−1.0	−14.0	--------	--------	2.0	−11.8

Maneuver: Level flight

Run No. 4, 1a — Run No. 4, 1b

Section		Initial air speed 78 m. p. h.				Initial air speed 96.3 m. p. h.			
		A	B	C	D	A	B	C	D
Orifice	1	−14.5	−6.0	−5.0	−1.0	−14.5	−6.0	−3.0	−1.0
	2	−13.7	−5.2	−2.5	.5	−13.7	−5.2	−1.7	.5
	3	−5.8	−2.8	−1.4	.7	−5.8	−2.8	−1.4	.8
	4	−13.0	−5.3	−1.3	−2.0	−16.2	−6.0	0	−2.4
	5	−1.5	−2.3	−2.5	−4.0	−7.0	−5.5	−2.5	−4.0
	6	−1.2	−1.0	0	−5.0	−1.0	−2.3	−2.8	−5.0
	7	8.0	5.0	2.3	.5	4.0	7.5	2.3	2.7
	8	13.0	1.0	.8	5.5	13.0	−3.5	0	5.0
	9	−10.0	−12.0	4.0	4.5	−12.0	−7.8	4.0	5.6
	10	−.7	−8.7	6.6	9.3	4.0	−6.6	7.3	11.2
	11	1.5	−2.5	8.0	5.0	4.5	−.9	10.5	7.0
	12	4.0	−1.5	1.9	1.0	10.0	−1.0	2.6	4.0
	13	--------	--------	.6	3.5	--------	--------	1.3	6.6
	14	--------	--------	−.8	−5.2	--------	--------	2.0	−1.0
	15	--------	--------	−3.1	−7.5	--------	--------	−1.5	−5.0
	16	--------	--------	−2.0	−5.0	--------	--------	−1.5	−4.5

		Run No. 4, 1c				Run No. 4, 2a			
Section		Initial air speed 113.8 m. p. h.				Initial air speed 132.7. m. p. h.			
		A	B	C	D	A	B	C	D
Orifice	1	−15.5	−4.3	0	0	−17.0	.6	5.0	.5
	2	−14.5	−4.0	−.7	1.2	−13.5	−.8	1.0	2.0
	3	−5.0	1.0	1.0	.7	−5.0	2.0	4.0	1.2
	4	−14.0	−3.5	3.3	−.4	−16.2	1.4	6.5	1.1
	5	−2.0	−1.6	−.8	−1.5	−7.8	−5.0	−.8	−2.5
	6	7.0	1.6	−.3	−2.5	−9.5	.5	−1.8	−1.5
	7	9.0	3.0	5.5	7.5	13.0	5.0	7.5	12.0
	8	13.0	3.5	1.2	3.3	22.8	1.0	2.5	3.3
	9	−11.2	−13.0	3.0	5.0	−21.0	−11.5	4.0	11.0
	10	4.0	−11.0	9.0	13.6	9.7	−10.5	10.8	16.8
	11	2.3	−5.6	11.5	8.5	7.5	−2.2	14.0	12.5
	12	−.5	−3.0	2.6	5.0	2.8	0	4.0	8.5
	13	--------	--------	.7	8.0	--------	--------	2.0	10.6
	14	--------	--------	2.0	2.5	--------	--------	5.6	7.8
	15	--------	--------	−3.5	−5.0	--------	--------	.5	−1.0
	16	--------	--------	−2.5	−5.0	--------	--------	−2.5	−4.5

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

		Run No. 4, 2b				Run No. 4, 2c			
Section		Initial air speed 148.6 m. p. h.				Initial air speed 165.5 m. p. h.			
		A	B	C	D	A	B	C	D
Orifice	1	−19.0	0	9.5	1.6	−19.8	3.0	14.5	2.8
	2	−15.5	−.3	1.5	3.0	−14.5	3.0	2.5	3.0
	3	−7.0	3.0	5.0	.7	−8.0	4.5	6.0	−2.0
	4	−21.2	1.4	8.3	.7	−24.3	2.5	9.0	.7
	5	−14.3	−6.0	−.8	−2.8	−22.0	−8.5	−.4	−1.5
	6	11.0	0	−1.0	−2.0	13.6	−2.8	−2.2	−1.0
	7	13.5	8.0	8.2	11.5	18.0	12.0	9.6	14.0
	8	26.0	−.5	3.3	4.3	33.0	−3.4	4.0	4.6
	9	−24.5	−11.5	4.0	14.0	−28.3	−11.0	6.7	17.5
	10	15.2	−10.5	13.0	21.0	21.2	−9.4	19.0	27.2
	11	13.2	−2.2	20.0	18.2	11.5	1.0	30.4	22.5
	12	4.5	1.0	4.4	10.5	4.5	2.5	5.0	13.6
	13	--------	--------	2.5	11.0	--------	--------	3.1	11.5
	14	--------	--------	8.2	9.6	--------	--------	11.0	18.5
	15	--------	--------	2.8	0	--------	--------	6.0	1.0
	16	--------	--------	−2.5	−5.5	--------	--------	−3.0	−3.6

Maneuver: Power-on dive — Maneuver: Power-off dive

Run No. 6, 1a — Run No. 6, 1b

Section		Air speed 200 m. p. h.				Air speed 200 m. p. h.			
		A	B	C	D	A	B	C	D
Orifice	1	−29.0	1.5	15.5	−3.5	−32.0	.5	11.0	−3.0
	2	−25.0	.5	1.5	−3.8	−21.0	1.2	−.5	−4.5
	3	−9.0	6.6	5.5	−6.5	−6.0	7.8	6.8	−4.7
	4	−31.0	2.0	11.0	−2.5	−28.5	4.8	12.5	−.7
	5	−25.5	−9.5	−5.5	−1.9	−18.0	−9.0	−3.5	−1.5
	6	16.5	−5.5	−6.2	−2.5	15.0	−6.5	−7.5	−2.5
	7	28.5	17.7	10.5	21.0	27.0	20.5	10.5	21.0
	8	45.0	−5.5	.5	−1.2	46.5	−10.0	0	0
	9	−44.0	−15.5	4.0	17.5	−40.0	−18.7	4.5	19.2
	10	25.5	−17.5	43.0	40.0	23.0	−22.8	34.0	40.0
	11	15.0	−2.8	51.0	29.5	11.5	−6.5	60.0	27.0
	12	−14.5	−6.0	0	13.0	−37.5	−12.5	−1.7	10.5
	13	--------	--------	1.2	9.0	--------	--------	−.6	5.0
	14	--------	--------	7.8	25.0	--------	--------	9.0	28.0
	15	--------	--------	3.0	--------	--------	--------	1.3	5.0
	16	--------	--------	−5.5	--------	--------	--------	−6.5	−6.3

Maneuver: Mild pull-out of a dive from zero lift

Run No. 7, 1a — Air speed at beginning of pull-out 192 m. p. h.

Section		0.15 sec.				0.65 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−42.5	−5.0	9.0	−1.5	−69.0	−16.9	−5.9	0
	2	−38.5	−4.5	−1.5	.5	−64.5	−17.8	−9.3	3.5
	3	−10.0	−.5	3.7	−2.0	−16.0	−12.3	−.8	3.7
	4	−41.0	−2.0	9.3	−.9	−69.5	−13.2	−2.0	1.0
	5	−22.0	−13.2	−8.7	−7.4	−2.0	−16.0	−12.6	−13.5
	6	13.0	−7.8	−10.0	−6.5	15.0	−13.0	−15.2	−14.0
	7	23.0	28.8	5.7	17.5	21.5	38.2	7.6	14.5
	8	43.0	−16.0	.3	7.0	52.5	−25.5	1.0	17.5
	9	−42.5	−17.5	8.4	23.5	−46.4	−24.0	15.0	21.5
	10	23.4	−20.2	37.5	38.4	18.6	−28.7	45.0	40.2
	11	11.8	−5.7	--------	29.0	15.0	−9.6	--------	30.0
	12	−22.0	−8.5	1.4	11.0	−9.0	−11.4	7.0	15.6
	13	--------	--------	1.0	6.6	--------	--------	2.2	20.5
	14	--------	--------	9.1	20.5	--------	--------	6.1	9.8
	15	--------	--------	.8	−2.0	--------	--------	−5.5	−16.6
	16	--------	--------	−5.4	−5.5	--------	--------	−13.0	−15.6

Section		1.15 sec.				1.65 sec.			
		A	B	C	D	A	B	C	D
Orifice	1	−83.5	−22.5	−11.5	0	−87.5	−23.8	−14.3	1.0
	2	−80.0	−22.0	−9.9	4.5	−82.5	−22.5	−11.0	4.5
	3	−18.0	−17.7	−4.0	6.0	−18.0	−16.5	−5.4	6.0
	4	−77.5	−17.5	−8.5	1.0	−76.0	−17.0	−6.0	2.0
	5	6.5	−17.0	−14.1	−14.5	9.3	−15.4	−12.1	−15.0
	6	18.0	−11.5	−15.9	−16.4	20.0	−9.5	−14.6	−16.0
	7	21.5	37.2	7.6	12.5	25.0	34.0	9.0	13.0
	8	57.3	−23.2	1.6	19.8	57.3	−18.4	2.6	19.8
	9	−46.4	−31.5	17.0	20.6	−46.4	−35.5	17.0	21.5
	10	14.4	−33.5	55.0	39.0	12.2	−36.5	53.0	39.5
	11	10.3	−12.7	--------	30.0	9.0	−16.0	--------	29.0
	12	−19.5	−14.4	8.0	14.2	−24.0	−15.5	8.0	14.2
	13	--------	--------	1.6	19.6	--------	--------	1.0	18.8
	14	--------	--------	2.0	.8	--------	--------	.6	−2.5
	15	--------	--------	−9.1	−22.5	--------	--------	−10.4	−22.0
	16	--------	--------	−17.3	−19.6	--------	--------	−19.5	−20.2

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Section	2.15 sec.				2.65 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−86.0	−22.5	−17.4	0	−78.0	−20.5	−11.5	−1.0
2	−82.5	−22.5	−13.2	4.5	−76.5	−21.0	−13.5	4.0
3	−17.0	−17.0	−5.4	5.5	−16.0	−13.6	−3.5	5.5
4	−73.0	−15.9	−6.0	2.7	−66.0	−13.5	−4.3	2.7
5	11.8	−14.4	−11.2	−14.0	11.8	−11.5	−9.7	−13.0
6	21.4	−7.8	−13.0	−16.0	23.0	−6.6	−12.0	−13.5
7	27.0	29.3	9.5	13.0	28.0	26.0	10.4	14.0
8	53.2	−14.4	3.0	19.0	53.4	−11.2	3.0	17.0
9	−43.3	−37.9	16.0	21.0	−42.5	−37.0	15.0	21.0
10	9.0	−37.5	53.0	39.0	9.0	−36.5	46.0	37.7
11	7.8	−16.5	--------	27.5	7.8	−16.5	--------	25.5
12	−23.0	−16.0	7.5	13.7	−26.0	−16.0	7.0	13.1
13	--------	--------	1.0	18.5	--------	--------	1.0	18.0
14	--------	--------	1.0	−2.0	--------	--------	0	.5
15	--------	--------	−10.4	−21.0	--------	--------	−11.0	−21.0
16	--------	--------	−19.5	−20.2	--------	--------	−17.3	−17.6

Section	3.15 sec.				3.65 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−68.0	−13.5	−7.0	−1.5	−59.5	−11.0	−4.1	−1.5
2	−65.5	−18.5	−13.2	3.5	−60.0	−15.3	−12.0	4.0
3	−14.0	−11.2	−1.9	4.3	−13.0	−9.3	−.8	3.7
4	−59.5	−12.3	−2.5	1.7	−50.0	−8.7	−1.4	1.7
5	11.0	−11.0	−9.1	−10.9	11.0	−8.5	−6.2	−8.5
6	22.0	−5.6	−9.6	−11.4	21.4	−3.5	−7.5	−8.6
7	27.0	23.2	10.7	13.0	31.5	17.7	11.7	14.0
8	49.0	−9.3	3.0	15.0	44.5	−3.4	3.2	11.9
9	−40.0	−33.9	13.2	21.0	−37.5	−34.3	11.0	20.6
10	9.0	−33.0	38.5	35.6	7.0	−33.0	30.0	33.5
11	8.5	−14.0	--------	25.0	7.0	−14.0	--------	22.5
12	−27.5	−14.4	6.2	12.6	−28.0	−14.4	5.7	12.1
13	--------	--------	1.6	18.0	--------	--------	1.0	16.4
14	--------	--------	0	3.0	--------	--------	−.5	3.7
15	--------	--------	−9.1	−19.1	--------	--------	−8.6	−15.5
16	--------	--------	−14.0	−17.2	--------	--------	−14.0	−15.0

Run No. 8, 2a Maneuver: Pull-up Initial air speed 130 m. p. h.

Section	0 sec.				0.57 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−27.5	−7.3	−3.0	−2.4	−51.0	−22.0	−23.0	−25.0
2	−26.5	−6.5	--------	0	−62.0	−21.0	--------	−7.0
3	−26.0	−5.0	2.2	−.8	−68.0	−24.0	−21.0	−5.0
4	−35.5	−5.7	3.0	−1.5	−67.0	−23.0	−16.0	−17.0
5	−11.0	−9.0	−6.0	−8.5	3.0	−9.0	−10.0	20.0
6	7.0	−3.5	−6.0	−8.0	−1.0	−11.0	−17.0	−25.0
7	12.5	14.0	5.0	5.0	1.0	33.0	−3.0	−15.0
8	29.5	−5.5	1.0	4.5	37.0	−25.0	−3.0	7.0
9	−27.0	−15.5	5.0	12.0	−26.0	−36.0	2.0	6.0
10	10.0	−13.0	15.6	21.0	−13.0	−31.0	26.0	19.0
11	7.0	−4.0	32.5	16.8	−4.0	−13.0	43.0	16.0
12	5.0	−5.5	3.4	8.4	19.0	−5.0	−4.0	4.0
13	--------	--------	1.0	10.5	--------	--------	−5.0	6.0
14	--------	--------	2.5	−2.5	--------	--------	−8.0	−29.0
15	--------	--------	−2.5	−10.5	--------	--------	−10.0	−26.0
16	--------	--------	−8.0	−12.0	--------	--------	−12.0	−22.0

Section	1.00 sec.				1.50 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−42.0	−21.3	−25.5	−19.5	−38.5	−19.0	−23.0	−17.0
2	−46.5	−20.5	--------	−17.5	−40.6	−15.5	--------	−10.5
3	−58.0	−25.6	−19.0	−4.0	−44.2	−16.7	−9.0	−3.0
4	−56.0	−24.0	−17.0	−15.8	−46.0	−15.5	−11.5	−7.8
5	−6.0	−8.0	−8.0	−17.5	−5.0	−8.0	−6.5	−12.5
6	−5.0	−10.0	−12.5	−19.0	−8.0	−7.0	−10.0	−16.0
7	−5.5	32.0	−3.0	−11.5	1.5	25.0	−.5	−8.0
8	33.5	−27.5	−2.5	5.5	23.0	−21.0	−1.5	7.0
9	−30.0	−20.0	0	3.6	−24.5	−12.5	2.0	5.0
10	−3.5	−21.0	20.0	15.7	1.5	−15.5	15.0	14.0
11	0	−5.0	32.0	15.9	4.0	−2.0	27.5	13.0
12	22.0	.5	2.2	6.0	16.0	.8	3.4	6.0
13	--------	--------	−2.5	7.5	--------	--------	0	8.5
14	--------	--------	−4.0	−18.0	--------	--------	−2.5	−13.0
15	--------	--------	−10.0	−19.5	--------	--------	−6.5	−16.5
16	--------	--------	−7.0	−18.5	--------	--------	−5.0	−14.5

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Run No. 8, 2b Maneuver: Pull-up Initial air speed 140 m. p. h.

Section	0.12 sec.				0.32 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−19.0	−2.0	5.0	−1.0	−45.0	−14.5	−8.5	−2.6
2	−17.0	−2.0	0	0	−46.5	−16.8	--------	0
3	−15.0	0	2.0	−3.0	−44.2	−13.8	−1.0	−.8
4	−26.0	−3.0	6.0	−1.0	−51.0	−11.0	−2.7	−2.5
5	−16.0	−9.0	−5.0	−5.0	−11.0	−9.0	−5.0	−9.0
6	11.0	−3.0	−5.0	−4.0	4.0	−5.5	−8.0	−9.0
7	14.0	10.0	6.0	12.0	16.0	15.5	5.5	10.0
8	27.0	−1.0	.5	4.0	33.5	−7.0	.5	5.5
9	−28.0	−14.0	4.0	12.0	−30.0	−21.0	7.0	13.5
10	14.0	−14.0	27.0	25.0	5.5	−18.0	24.0	24.0
11	10.0	−1.0	33.0	18.0	8.0	−5.0	38.0	18.0
12	0	−1.0	2.0	11.0	3.0	−25.0	4.0	9.5
13	--------	--------	3.0	11.0	--------	--------	.5	11.0
14	--------	--------	5.0	10.0	--------	--------	2.0	0
15	--------	--------	0	−4.0	--------	--------	−4.0	−23.5
16	--------	--------	−3.0	−6.0	--------	--------	−8.0	−14.5

Section	0.72 sec.				1.32 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−64.0	−24.0	−26.0	−25.0	−46.2	−23.0	−29.0	−21.4
2	−74.0	−26.0	--------	−4.0	−51.0	−20.5	--------	−11.0
3	−83.0	−26.0	−24.0	−4.0	−62.3	−25.0	−14.0	−3.5
4	−61.0	−28.0	−19.0	−21.0	−59.0	−26.0	−15.0	−18.4
5	3.0	−12.0	−11.0	−24.0	−4.0	−7.0	−7.0	−19.0
6	−3.0	−13.0	−17.0	−29.0	−6.0	−10.0	−12.0	−18.5
7	4.0	32.0	−3.0	−14.0	.5	31.0	−2.0	−9.0
8	41.0	−25.0	−3.0	9.0	33.5	−26.5	−2.0	8.0
9	−30.0	−41.0	3.0	7.0	−30.5	−21.0	4.0	6.4
10	−13.0	−34.0	22.0	23.0	−3.0	−23.0	17.5	19.0
11	−5.0	−14.0	47.0	19.0	1.0	−6.5	25.0	17.2
12	19.0	−5.0	−4.0	4.0	23.0	−1.0	2.2	7.4
13	--------	--------	−6.0	7.0	--------	--------	−2.0	8.5
14	--------	--------	−8.0	−33.0	--------	--------	−4.0	−20.5
15	--------	--------	−10.0	−28.0	--------	--------	−9.0	−21.0
16	--------	--------	−13.0	−24.0	--------	--------	−7.0	−21.0

Run No. 9, 1a Maneuver: Pull-up, power on Initial air speed 156 m. p. h.

Section	0 sec.				0.25 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−25.5	−0.5	8.5	−2.3	−41.5	−8.8	−2.5	−1.5
2	−12.5	.5	--------	−2.7	−36.0	−8.4	--------	.8
3	−18.0	3.0	4.5	−.8	−32.0	−5.3	0	1.8
4	−26.5	1.2	8.3	−.5	−36.0	−6.5	2.8	−.5
5	−14.5	−6.0	−1.8	−1.3	−5.0	−5.2	−7.8	−4.5
6	18.0	−1.6	−2.2	−.5	17.0	−2.5	−5.0	5.5
7	23.9	9.0	10.5	10.9	22.0	12.5	9.5	9.0
8	34.5	2.4	.5	−.5	37.5	1.5	3.0	9.0
9	−35.2	−16.4	3.5	16.3	−36.3	−24.2	8.2	18.7
10	18.0	−13.0	37.5	27.8	11.8	−21.7	37.5	28.6
11	12.2	−5.3	36.7	20.3	8.5	−10.5	40.7	20.3
12	−4.9	−5.0	3.0	12.9	−4.3	−7.4	5.4	11.2
13	--------	--------	1.6	11.4	--------	--------	3.3	16.4
14	--------	--------	6.0	13.5	--------	--------	3.3	3.5
15	--------	--------	2.7	−2.0	--------	--------	−2.5	−12.5
16	--------	--------	−8.0	−7.6	--------	--------	−13.0	−12.5

Section	0.50 sec.				0.75 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−77.5	−27.3	−26.5	−9.5	−83.5	--------	−34.5	−24.0
2	−80.0	−25.5	--------	.8	−91.0	--------	--------	−8.6
3	−76.4	−20.5	−12.5	2.4	−100.0	--------	--------	−9.8
4	−78.3	−25.0	−8.0	−7.3	−97.0	--------	--------	−18.5
5	10.0	−9.0	−15.5	−18.4	5.0	−12.0	−17.5	−25.7
6	11.0	−7.5	−13.0	20.5	.9	−14.5	−18.0	31.5
7	16.4	24.3	4.2	5.4	5.5	35.5	−2.3	−14.5
8	43.5	−13.0	3.4	18.7	45.5	−29.0	−3.0	13.5
9	−34.0	−40.5	11.8	16.6	−33.0	−47.2	5.4	10.3
10	−3.8	−35.5	27.5	29.5	−16.0	−39.5	29.0	26.5
11	−1.8	−17.0	51.5	20.3	−6.4	−18.8	--------	20.3
12	4.5	−12.0	3.0	6.5	16.9	−8.2	−3.5	2.7
13	--------	--------	−2.5	15.0	--------	--------	−7.5	8.2
14	--------	--------	−5.0	−23.0	--------	--------	−10.0	−33.5
15	--------	--------	−11.5	−29.0	--------	--------	−16.0	−32.5
16	--------	--------	−21.0	−25.3	--------	--------	−18.0	−30.6

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Section	1.00 sec.				1.50 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−64.5		−31.5		−51.0		−21.5	−22.5
2	−78.0			−15.0	−53.5	−20.5		−10.5
3	−90.5			−12.5	−61.5		−16.5	−3.5
4	−89.0			−19.5	−61.0	−27.8	−19.0	−10.5
5	−3.0	−11.8	−13.4	−23.2	−6.7	−8.4	−8.5	−14.5
6	−7.8	−16.0	−18.5	26.4	−7.8	−12.0	−13.6	19.5
7	−2.5	40.5	−4.0	−15.5	−2.5	34.0	−1.0	−8.5
8	43.0	−38.2	−4.0	10.8	33.5	−31.5	−2.5	10.8
9	−33.0	−35.3	3.5	7.5	−30.5	−17.4	5.4	7.5
10	−6.4	−29.0	22.5	24.3	3.4	−19.0	18.2	18.2
11	−5.0	−13.5	48.5	19.2	4.0	−7.5	32.8	17.5
12	24.3	−4.5	0	5.1	19.0	−3.0	5.4	7.5
13			−5.7	10.0			−.5	13.0
14			−8.0	−28.3			−3.0	−18.0
15			−11.0	−28.0			−6.5	−19.8
16			−13.0	−26.8			−8.0	−22.5

Run No. 9, 1b Maneuver: Pull-up, power on Initial air speed 163 m.p.h.

Section	0 sec.				0.25 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−43.6	−12.0	0	−2.8	−82.5		−28.5	−11.5
2	−46.5	−11.7		−2.6	−92.5			0
3	−44.0	−3.7	−.8	1.5	−93.0	−26.0	−18.8	−1.0
4	−48.0	−11.0	1.9	−2.4	−93.0	−30.5		−13.0
5	−10.7	−11.0	−6.5	−6.5	0	−13.5	−14.5	−22.2
6	14.6	−3.9	−8.0	6.5	1.5	−12.6	−19.0	25.7
7	21.5	19.5	8.4	8.0	11.5	39.0	3.0	0
8	42.0	−5.6	3.0	9.0	49.0	−23.2	1.6	19.6
9	−39.2	−19.0	8.2	20.4	−40.5	−36.0	11.0	15.4
10	15.0	−18.5	37.5	30.4	−2.2	−36.4	30.0	29.5
11	10.8	−6.7		24.5	2.1	−15.5		24.2
12	2.0	−7.0	5.4	14.0	13.0	−7.4	5.0	9.2
13			2.2	15.0			−1.3	15.5
14			7.0	15.5			−5.0	22.0
15			0	−14.5			−11.0	−36.0
16			−10.5	−17.0			−23.2	−31.6

Section	0.50 sec.				0.75 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−87.0			−22.5	−78.0	−29.0	−45.0	−34.0
2	−92.5			−1.0	−80.2	−31.0		−6.1
3	−110.0			−12.0	−99.0	−29.0	−23.0	−12.0
4				−15.8	−91.5	−29.0	−30.0	−18.4
5	3.2	−12.5	−18.1	−33.6	−1.5	−11.5	−15.6	−25.6
6	−8.5	−19.0	−23.4	38.0	−10.5	−17.4	−21.0	31.5
7	−4.0	46.5	−6.1	−18.5	−6.5	45.2	−4.0	−14.3
8	51.5	−45.5	−4.0	11.0	46.5	−46.5	−4.0	9.4
9	−41.5	−38.6	5.5	7.8	−40.0	−29.3	2.8	6.7
10	−7.2	−35.5	10.5	26.7	−4.0	−29.0	30.0	24.2
11	−5.0	−19.0		22.3	.6	−13.5	56.5	21.5
12	23.0	−5.4	0	7.3	26.5	−3.0	3.3	7.8
13			−6.4	12.5			−4.4	12.0
14			−9.5	−37.4			−6.5	−27.5
15			−13.6	−39.0			−10.7	−31.6
16			−18.8	−38.5			−14.0	−32.3

Section	1.00 sec.				1.25 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−69.0				−62.0			−24.0
2	−68.0			−15.5	−62.0			−14.0
3	−85.0		−21.5	−9.3	−76.5		−18.8	−5.7
4	−80.5			−15.8	−71.0	−25.0	−20.5	−13.0
5	−5.5	−10.5	−12.5	−22.7	−5.0	−11.0	−8.8	−19.5
6	−9.0	−14.5	−18.0	25.3	−5.0	−11.7	−15.0	22.2
7	−4.0	40.7	−2.9	−12.4	0	31.7	−1.1	−9.5
8	39.8	−40.9	−2.5	11.0	37.5	−34.0	−2.0	12.0
9	−37.5	−21.0	4.4	8.3	−34.0	−20.6	7.0	9.3
10	2.6	−22.6	22.5	21.5	.8	−21.7	20.2	21.5
11	3.9	−10.0	56.5	19.8	3.0	−8.8	43.5	17.4
12	23.0	−2.0	5.8	8.9	18.5	−4.0	5.0	7.8
13			−1.7	13.3			−1.7	13.0
14			−3.5	−22.5			−3.5	−20.0
15			−8.1	−24.4			−8.1	−20.1
16			−9.5	−27.5			−9.5	−22.1

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Run No. 9, 2a Maneuver: Pull-up, power off Initial air speed 133 m. p. h.

Section	0.12 sec.				0.57 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−31.0	−6.0	−3.5	−0.5	−53.5	−21.5	−23.0	−5.7
2	−27.0	−8.0		1.0	−54.5	−20.5		−5.2
3	−27.0	−3.0	−.5	2.0	−58.0	−18.2	−11.7	−3.5
4	−26.0	−4.5	1.0	0	−54.0	−22.0	−18.4	−11.5
5	−3.0	−9.0	−6.0	−5.5	3.0	−9.5	−8.8	−12.0
6	4.0	−5.0	−6.0	3.0	−2.5	−10.5	−12.5	14.0
7	9.0	16.0	4.0	5.5	−2.5	25.5	−.7	−4.6
8	22.0	−11.0	1.0	7.0	25.0	−23.8	.2	8.0
9	−22.0	−10.5	5.5	10.0	−23.0	−18.0	2.5	7.0
10	8.0	−12.0	13.0	15.5	0	−20.2	12.5	14.5
11	4.0	−5.0	25.0	15.0	−.5	−8.7	24.5	12.4
12	−6.5	−5.5	3.0	7.0	−1.0	−6.5	1.0	5.0
13			1.0	9.5			−1.2	6.8
14			3.0	4.5			−2.5	−14.0
15			−2.5	−4.0			−8.7	−17.0
16			−6.0	−5.5			−11.0	−16.8

Section	0.90 sec.				1.22 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−59.0	−31.0	−31.5	−25.0	−49.0	−24.0	−23.0	−17.0
2	−56.0	−25.5		−16.0	−44.5	−18.0		−14.0
3	−57.0	−26.0	−24.0	−12.5	−47.0	−20.7	−22.8	−9.6
4	−48.0	−26.6	−30.0	−21.0	−39.0	−19.3	−26.0	−21.0
5	5.0	−9.5	−10.0	−16.6	4.5	−7.0	−10.0	−14.0
6	−5.0	−10.0	−14.0	15.5	−3.8	−7.5	10.3	13.0
7	−6.0	28.5	−4.0	−10.0	−6.5	23.0	−3.0	−6.4
8	24.0	−27.5	−2.0	1.5	21.0	−24.8	−2.0	2.7
9	−20.0	−23.5	−1.5	1.0	−18.5	−18.5	−1.2	1.5
10	−8.0	−21.7	13.0	12.0	−5.5	−18.0	10.2	10.5
11	−4.0	−11.0	21.0	9.5	−2.5	−8.7	16.5	8.5
12	7.0	−7.0	−1.0	1.5	7.5	−4.5	0	1.0
13			−4.0	2.0			−2.2	1.0
14			−7.5	−20.5			−5.0	−15.8
15			−12.0	−22.0			−8.7	−16.5
16			−12.5	−24.0			−8.7	−16.0

Run No. 9, 2b Maneuver: Pull-up, power off Initial air speed 162 m. p. h.

Section	0.05 sec.				0.40 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−44.0	−7.0	−5.0	−1.0	−72.0	−23.0	−28.5	−17.0
2	−36.0	−10.0		−1.0	−77.5	−23.0		−2.8
3	−37.0	−2.0	0	3.0	−88.5	−24.8	−20.0	−5.5
4	−31.0	−6.5	−1.0	0	−82.0	−31.0	−30.0	−14.8
5	−7.0	−10.5	−5.0	−7.4	4.5	−12.0	−11.0	−16.3
6	10.0	−6.5	−8.0	3.0	1.8	−12.5	−16.0	15.5
7	15.0	20.5	6.0	11.0	3.0	31.4	0	−5.2
8	35.0	−12.0	1.5	9.5	39.5	−25.8	.2	14.4
9	−31.0	−16.0	9.0	17.0	−32.5	−27.8	8.0	12.3
10	9.0	−21.5	22.5	24.0	−3.3	−30.0	20.0	22.0
11	4.5	−10.0	38.0	21.5	−1.6	−12.8	48.5	18.5
12	−20.0	−10.0	4.0	12.0	−3.0	−11.0	3.5	7.5
13			.3	13.0			−1.2	11.0
14			5.5	7.0			−3.0	−19.3
15			−1.5	−4.5			−12.0	−26.0
16			−8.0	−6.0			−16.8	−17.5

Section	0.75 sec.				1.25 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−67.0	−31.5	−35.0	−25.5	−56.0	−22.0	−23.0	−22.5
2	−87.0	−38.5		−15.0	−56.3	−23.0		−15.3
3	−88.0	−34.0	−26.0	−14.5	−63.0	−23.0	−23.6	−4.3
4	−86.0	−28.5	−46.0	−25.5	−55.3	−23.5	−26.0	−17.0
5	7.0	−13.0	−15.0	−24.0	0	−10.5	−10.5	−16.0
6	−5.0	−15.0	−19.0	23.0	−6.3	−10.8	−13.0	15.0
7	−8.0	39.5	−5.0	−12.5	−8.3	31.0	−2.4	−7.3
8	38.0	−35.5	1.5	4.0	28.0	−29.5	−1.5	7.5
9	−30.0	−34.0	−1.5	2.5	−26.0	−16.4	2.0	4.4
10	−11.0	−31.0	24.0	18.0	1.5	−19.0	16.5	14.0
11	−5.0	−15.5	41.0	16.0	1.5	−7.3	31.0	12.0
12	13.0	−9.0	−3.0	2.0	9.5	−6.0	2.7	6.0
13			−7.0	6.0			−1.7	7.8
14			−10.0	−29.0			−4.0	−15.0
15			−16.5	−34.0			−8.7	−20.0
16			−19.5	−32.0			−9.5	−20.3

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Run No. 12, 2a Maneuver: Left spin

Section	0 sec.				0.37 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−13.5	−7.0	−8.0	−7.0	−16.5	−9.5	−10.5	−8.5
2	−15.5	−8.0	--------	−6.5	−16.0	−10.0	--------	−10.0
3	−14.0	−7.5	−7.0	−2.8	−16.0	−8.5	−7.0	−5.4
4	−13.0	−9.0	−8.5	−10.5	−15.0	−11.0	−9.6	−9.5
5	2.5	−1.7	−1.0	−6.5	.5	−2.0	−2.7	−7.0
6	−1.5	−1.8	−3.7	1.5	−5.0	−3.5	−5.0	3.5
7	−2.0	6.5	−2.0	−3.5	−7.0	10.5	−4.0	−5.5
8	5.5	−6.0	0	0	4.0	−12.6	−1.0	−3.0
9	−4.0	−7.0	−1.0	4.5	−6.0	−5.5	−4.5	2.5
10	−4.0	−6.5	3.0	3.5	−3.0	−5.3	3.0	3.0
11	−2.0	−3.0	4.0	2.8	−3.0	−2.3	4.0	3.0
12	4.0	−1.0	−2.7	−3.5	3.0	0	−1.8	−3.0
13	--------	--------	−2.3	−1.0	--------	--------	−2.5	−1.5
14	--------	--------	−3.5	−8.8	--------	--------	−3.5	−9.4
15	--------	--------	−4.5	−6.0	--------	--------	−4.5	−6.5
16	--------	--------	−3.0	−5.5	--------	--------	−2.5	−6.5

Section	1.23 sec.				2.33 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−14.5	−12.0	−11.0	−10.5	−20.0	−12.0	−13.2	−11.2
2	−15.5	−9.0	--------	−9.0	−22.0	−13.0	--------	−12.0
3	−16.3	−7.5	−6.5	−5.0	−22.0	−10.0	−8.6	−10.0
4	−13.0	−8.0	−5.5	−6.5	−21.0	−12.8	−10.5	−9.5
5	−7.0	−4.5	−2.7	−7.0	−7.0	−4.8	−4.0	−9.5
6	−6.5	−6.5	−6.5	2.5	−8.5	−7.0	−7.0	7.0
7	−15.0	12.5	−4.5	−7.0	−15.0	16.5	−7.0	−10.5
8	−3.5	−16.5	−7.7	−6.0	1.0	−23.5	−3.5	−6.7
9	−8.0	6.0	−9.0	−2.5	−8.3	−1.0	−9.5	−1.0
10	5.3	3.5	2.0	.5	0	−2.5	3.4	1.5
11	4.5	3.3	2.5	4.0	−3.5	−.5	2.8	3.0
12	8.5	4.5	5.0	1.0	4.5	1.5	2.0	−1.0
13	--------	--------	2.5	5.5	--------	--------	−1.5	1.5
14	--------	--------	2.5	−2.0	--------	--------	−2.0	−8.5
15	--------	--------	−.5	−3.5	--------	--------	.5	−9.0
16	--------	--------	.5	−3.5	--------	--------	−2.0	−8.5

Section	3.00 sec.				4.29 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−19.0	−11.0	−11.5	−14.0	−18.0	−12.0	−14.5	−13.0
2	−17.0	−13.0	--------	−11.3	−18.0	−15.5	--------	−13.3
3	−17.5	−10.0	−9.0	−10.0	−20.5	−14.0	−11.6	−8.5
4	−17.0	−11.5	−8.5	−6.5	−20.0	−15.8	−13.5	−12.0
5	−9.5	−4.8	−4.0	−11.4	5.0	−4.5	−4.0	−11.4
6	−10.0	−7.5	−7.0	8.0	−10.0	−8.0	−6.5	8.0
7	−21.0	14.0	−7.0	−9.5	−16.3	15.0	−7.5	−10.0
8	−4.0	−20.0	−7.0	−9.0	.5	−22.5	−5.0	−8.6
9	−8.3	4.0	−13.5	−5.0	−8.0	−2.8	−12.5	−1.5
10	3.0	1.6	−.8	1.3	−3.0	3.5	1.5	2.5
11	−1.5	2.0	2.5	4.0	−4.0	−1.8	2.8	4.0
12	5.0	3.5	5.0	1.0	−7.0	−1.0	0	−.5
13	--------	--------	1.0	5.0	--------	--------	−2.5	.6
14	--------	--------	.6	−6.6	--------	--------	−4.5	−10.5
15	--------	--------	−2.5	−8.0	--------	--------	−5.0	−10.5
16	--------	--------	0	−7.0	--------	--------	−2.0	−9.5

Section	5.00 sec.				6.00 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−18.9	−15.3	−14.3	−11.1	−17.0	−13.8	−13.7	−12.0
2	−14.6	−14.7	--------	−15.0	−16.0	−14.4	--------	−14.0
3	−17.0	−13.6	−12.5	−10.9	−16.2	−12.6	−11.5	−9.8
4	−19.1	−14.4	−11.0	−10.4	−18.4	−13.5	−11.6	−9.7
5	−9.3	−5.3	−4.0	−11.4	−7.0	−5.3	−4.4	−10.0
6	−13.0	−8.4	−5.0	9.7	−12.1	−8.0	−5.4	7.2
7	−21.6	12.6	−7.5	−9.0	−19.8	13.5	−7.5	−8.5
8	−4.1	−21.8	−7.0	−9.9	−3.5	−23.2	−6.0	−8.9
9	−8.5	3.0	−15.0	−3.5	−7.9	.9	−13.1	−2.5
10	1.0	.3	0	2.2	−1.0	−1.5	0	2.2
11	−5.5	0	3.5	4.0	−4.8	−.6	3.5	3.7
12	0	3.2	3.5	3.6	−.5	1.9	1.8	3.0
13	--------	--------	0	3.0	--------	--------	−.4	2.0
14	--------	--------	−.5	−8.7	--------	--------	−2.0	−9.7
15	--------	--------	−3.5	−8.8	--------	--------	−4.5	−9.4
16	--------	--------	0	−6.7	--------	--------	−1.0	−7.5

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Section	6.50 sec.				7.00 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−20.0	−14.3	−15.0	−13.4	−18.0	−15.3	−13.0	−12.3
2	−18.3	−16.0	--------	−13.0	−15.5	−14.7	--------	−15.5
3	−19.0	−14.2	−13.3	−14.1	−16.2	−13.5	−12.1	−6.5
4	−19.1	−12.5	−9.6	−8.4	−18.4	−13.1	−12.1	−10.4
5	−11.5	−6.5	−3.4	−11.8	−4.9	−5.3	−4.0	−10.9
6	−14.5	−9.5	−6.3	10.2	−12.1	−8.0	−6.0	8.6
7	−22.0	14.1	−8.5	−10.5	−19.8	13.0	−8.2	−9.5
8	−6.5	−18.2	−7.8	−10.9	−5.0	−20.3	−7.0	−9.9
9	−7.9	3.0	−15.6	−3.5	−7.0	2.0	−15.0	−3.0
10	2.0	.3	−.3	1.5	.5	.6	0	2.2
11	−2.3	1.0	4.0	4.0	−4.0	0	4.0	3.7
12	3.0	3.2	3.5	4.0	1.0	2.8	2.7	3.5
13	--------	--------	0	3.6	--------	--------	−.6	2.6
14	--------	--------	−.5	−8.1	--------	--------	−1.4	−9.0
15	--------	--------	−3.5	−8.4	--------	--------	−4.0	−9.4
16	--------	--------	0	−6.7	--------	--------	−.5	−8.0

Section	8.00 sec.				9.00 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−14.0	−14.3	−16.6	−11.1	−15.0	−14.3	−16.1	−12.3
2	−17.0	−15.5	--------	−16.5	−16.0	−14.4	--------	−15.5
3	−17.0	−13.5	−13.0	−3.5	−18.0	−13.2	−11.0	−6.5
4	−18.4	−16.8	−12.7	−15.7	−18.4	−15.5	−13.4	−15.7
5	−3.9	−4.9	−4.4	−9.4	−2.0	−4.4	−4.4	−9.0
6	−10.3	−7.5	−5.4	7.6	−9.8	−6.7	−5.0	7.2
7	−15.5	12.1	−7.0	−9.0	−15.0	12.1	−6.5	−8.5
8	−2.0	−19.8	−5.8	−8.5	0	−18.7	−4.8	−7.2
9	−6.5	−3.3	−11.8	−.5	−5.8	−4.4	−11.1	−.5
10	−3.0	−4.0	1.8	3.0	−3.9	−4.5	1.8	2.5
11	−6.8	−2.3	4.0	3.1	−5.5	−2.3	3.0	3.1
12	−3.0	.7	−1.3	1.5	−10.5	0	−1.3	1.6
13	--------	--------	−2.7	−.5	--------	--------	−2.7	−.5
14	--------	--------	−.5	−10.6	--------	--------	−4.5	−9.7
15	--------	--------	−5.0	−10.0	--------	--------	−5.5	−9.4
16	--------	--------	−2.1	7.6	--------	--------	−2.1	−8.4

Run No. 13, 2a Maneuver: Right spin

Section	0 sec.				1.0 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−12.5	−7.5	−8.3	−5.5	−10.0	−6.0	−7.0	−4.5
2	−15.5	−6.0	--------	−5.0	−12.0	−4.5	--------	−1.5
3	−12.5	−5.5	−6.0	−1.0	−10.8	−4.0	−4.6	−2.0
4	−12.0	−5.7	−4.4	−5.0	−11.0	−4.5	−3.0	−4.3
5	−.8	−1.5	−2.5	−3.0	3.8	−1.3	−1.5	−3.0
6	−2.5	−2.7	−2.6	4.0	0	0	−1.0	3.5
7	−3.5	8.0	−1.0	−4.0	.7	3.5	0	−3.0
8	4.0	−10.0	.3	−1.0	5.0	−3.0	.3	.5
9	−5.4	−3.4	−1.5	0	−2.6	−6.7	.6	1.0
10	−1.0	−3.5	3.0	1.0	−3.0	−5.8	3.0	1.0
11	0	−2.3	3.5	3.0	−1.0	−3.0	2.5	1.7
12	4.0	−1.0	1.0	1.0	0	−1.5	−1.0	0
13	--------	--------	0	1.0	--------	--------	−1.5	0
14	--------	--------	−1.0	−4.0	--------	--------	−2.0	−4.0
15	--------	--------	−2.5	−4.0	--------	--------	−2.5	−3.5
16	--------	--------	−2.0	−4.0	--------	--------	−2.5	−3.0

Section	1.50 sec.				2.0 sec.			
Orifice	A	B	C	D	A	B	C	D
1	−9.5	−5.0	−4.5	−2.5	−9.5	−4.0	−3.0	−1.5
2	−10.0	−3.4	--------	−1.0	−11.0	−3.0	--------	.5
3	−9.7	−2.2	−3.0	−1.0	−9.0	−1.7	−2.3	0
4	−9.0	−3.0	−2.6	−2.5	−9.0	−2.5	−2.0	−2.5
5	5.0	−.8	−1.0	−2.7	3.8	−.8	−1.0	−2.5
6	1.8	.5	−.6	3.0	1.8	0	−.6	3.0
7	2.5	.8	.8	−2.0	2.5	1.5	.8	−1.5
8	5.0	−.5	.6	2.0	5.0	−1.2	.6	2.5
9	−2.0	−8.2	1.5	1.6	−2.6	−6.7	1.5	2.0
10	−3.7	−5.8	3.0	1.3	−2.0	−5.2	3.0	1.3
11	−2.0	−2.8	2.5	1.7	−1.0	−2.3	2.5	2.0
12	−1.1	−1.5	−.8	−.5	−1.7	−1.5	0	.8
13	--------	--------	0	0	--------	--------	0	1.0
14	--------	--------	−1.4	−3.5	--------	--------	−1.0	−3.0
15	--------	--------	−2.5	−2.5	--------	--------	−2.5	−2.5
16	--------	--------	−2.5	−2.0	--------	--------	−2.0	−1.5

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Section	3.0 sec.				3.5 sec.			
	A	B	C	D	A	B	C	D
Orifice 1	−15.0	−7.6	−8.6	−5.5	−19.0	−13.5	−16.8	−14.0
2	−17.0	−5.5	--------	−4.5	−23.0	−10.4	--------	−12.8
3	−16.5	−6.0	−7.0	−1.5	−19.5	−9.0	−11.0	−6.0
4	−15.5	−6.5	−6.0	−4.5	−16.5	−11.0	−8.4	−9.5
5	−1.0	−3.4	−3.5	−4.0	−5.0	−4.0	−4.5	−7.0
6	−4.0	−4.0	−4.0	4.0	−6.0	−5.0	−5.0	10.0
7	−6.5	11.0	−2.0	−5.0	−12.4	14.0	−4.5	−8.5
8	3.4	−13.5	0	−1.0	2.0	−22.5	−2.0	−6.0
9	−7.0	−.5	−2.5	−1.0	−7.5	−1.0	−8.0	−4.5
10	2.0	−1.5	2.8	1.3	2.0	−1.0	3.4	0
11	2.5	−1.0	4.0	3.0	1.0	−1.3	2.5	3.3
12	6.5	.5	1.8	1.0	5.0	1.4	2.7	2.6
13	--------	--------	.5	2.7	--------	--------	.5	3.5
14	--------	--------	0	−4.5	--------	--------	−.5	−5.0
15	--------	--------	−2.0	−4.5	--------	--------	−3.0	−6.5
16	--------	--------	−1.5	−5.0	--------	--------	−2.5	−6.4

Section	4.0 sec.				4.5 sec.			
	A	B	C	D	A	B	C	D
Orifice 1	−19.7	−14.4	−16.5	−16.0	−20.0	−10.5	−12.0	−8.5
2	−21.0	−12.3	--------	−12.0	−24.0	−10.4	--------	−3.0
3	−18.0	−12.8	−12.5	−11.0	−22.5	−11.0	−10.5	−8.5
4	−18.5	−13.4	−10.5	−15.7	−22.0	−12.0	−9.5	−12.0
5	5.0	−1.5	−3.0	−8.5	8.0	−.8	−2.0	−8.5
6	−5.5	−4.0	−4.0	10.5	2.0	−1.0	−3.5	8.3
7	−7.0	10.7	−4.5	−7.4	1.5	4.0	−.3	−5.5
8	6.0	−16.5	−2.0	−6.2	8.5	−2.5	0	1.0
9	−6.5	−7.0	−8.5	−3.0	−4.0	−15.5	.6	1.5
10	−5.0	−6.7	4.0	.6	−9.0	−11.5	4.4	2.6
11	−4.5	−4.5	4.5	3.0	−4.0	−6.0	5.0	3.0
12	0	−1.5	−1.5	.8	−3.0	−3.3	−4.5	−2.0
13	--------	--------	−3.0	−.5	--------	--------	−3.0	−2.0
14	--------	--------	−4.5	−9.0	--------	--------	−5.0	−9.5
15	--------	--------	−4.5	−8.2	--------	--------	−5.5	−7.5
16	--------	--------	−4.5	−7.5	--------	--------	−5.5	−6.0

Section	5.0 sec.				6.0 sec.			
	A	B	C	D	A	B	C	D
Orifice 1	−19.0	−10.5	−14.0	−6.0	−24.0	−12.4	−16.0	−8.5
2	−26.0	−10.4	--------	−6.0	−33.0	−10.4	--------	−12.0
3	−25.0	−8.5	−11.0	−8.0	−27.0	−9.3	−12.5	−10.4
4	−24.5	−11.5	−10.5	−9.6	−25.0	−16.0	−11.5	−12.0
5	9.0	0	−2.5	−10.0	13.8	2.4	−.6	−9.0
6	2.2	.5	−3.5	9.0	5.8	2.5	−1.8	7.5
7	2.5	4.0	−.3	−6.0	7.5	−1.0	2.4	−5.0
8	9.5	−2.5	.6	1.5	8.5	4.0	3.0	5.0
9	−3.0	−17.5	1.6	2.0	3.0	−2.7	4.8	4.5
10	−9.0	−13.0	4.4	3.4	−16.0	−18.5	4.4	4.0
11	−4.0	−6.5	5.5	3.0	−6.4	−9.3	6.0	2.0
12	−4.0	−4.5	−5.0	−2.5	−9.0	−6.0	−10.0	−6.5
13	--------	--------	−3.0	−2.5	--------	--------	−6.0	−5.3
14	--------	--------	−5.5	−11.5	--------	--------	−7.0	−15.4
15	--------	--------	−6.0	−9.0	--------	--------	−7.5	−11.0
16	--------	--------	−6.3	−6.5	--------	--------	−7.0	−8.0

TABLE II—Continued

COWLING PRESSURES—Continued

(Lbs. per sq. ft.)

Section	7.0 sec.				8.0 sec.			
	A	B	C	D	A	B	C	D
Orifice 1	−27.0	−10.5	−17.0	−8.5	−27.0	−17.2	−15.5	−9.0
2	−34.5	−11.5	--------	−14.0	−34.4	−15.5	--------	−14.4
3	−27.0	−9.3	−12.0	−10.4	−32.0	−11.2	−14.4	−11.4
4	−24.0	−17.8	−14.0	−13.7	−30.3	−17.5	−12.7	−12.0
5	16.5	4.5	0	−7.2	14.3	2.0	−1.8	−10.5
6	9.5	5.0	0	5.5	5.5	2.0	−2.9	8.2
7	10.5	−5.5	4.4	−2.0	7.0	1.0	1.7	−6.6
8	10.0	8.5	5.0	8.0	11.5	2.5	2.5	3.6
9	4.0	−31.7	8.0	6.0	−1.4	−29.5	4.1	4.5
10	−19.0	−20.5	3.4	5.0	−17.9	−20.6	6.4	4.6
11	−7.5	−10.5	6.6	0	−7.8	−10.0	7.0	2.0
12	−10.8	−6.0	−12.6	−9.4	−9.9	−7.5	−9.8	−6.0
13	--------	--------	−8.5	−6.5	--------	--------	−5.8	−6.2
14	--------	--------	−7.0	−14.8	--------	--------	−8.9	−17.8
15	--------	--------	−8.0	−11.0	--------	--------	−7.5	−12.8
16	--------	--------	−7.0	−8.5	--------	--------	−8.0	−8.4

Section	9 sec.				10 sec.			
	A	B	C	D	A	B	C	D
Orifice 1	−30.0	−16.5	−15.5	−12.3	−28.0	−15.3	−15.0	−9.0
2	−36.1	−16.0	--------	−14.0	−34.4	−16.5	--------	−14.4
3	−28.5	−11.2	−14.0	−12.5	−28.5	−10.7	−14.0	−13.0
4	−26.3	−19.9	−17.0	−15.0	−26.3	−19.9	−16.0	−15.0
5	17.0	4.5	.5	−8.2	17.0	4.0	0	−8.5
6	9.7	4.9	0	5.4	8.9	4.1	−.8	5.7
7	11.5	−4.5	4.8	−3.0	10.5	−3.5	3.7	−3.0
8	10.1	8.4	5.2	7.5	11.0	6.6	5.0	7.0
9	−5.0	−35.4	8.0	6.5	3.6	−33.1	7.4	6.5
10	−21.7	−22.7	4.3	5.0	−20.9	−22.2	3.8	5.0
11	−9.1	−10.0	6.0	−.2	−7.8	−10.0	6.5	0
12	−13.5	−8.5	−13.5	−9.8	−12.0	−8.5	−13.0	−8.6
13	--------	--------	−7.9	−9.0	--------	--------	−9.8	−9.0
14	--------	--------	−9.2	−18.3	--------	--------	−9.8	−17.8
15	--------	--------	−8.0	−13.5	--------	--------	−8.5	−12.8
16	--------	--------	−8.0	−9.7	--------	--------	−8.0	−10.3

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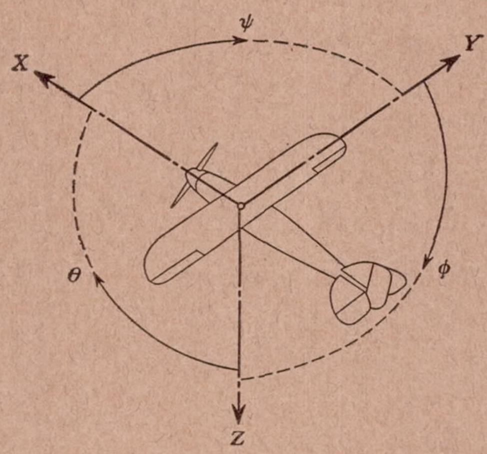

Positive directions of axes and angles (forces and moments) are shown by arrows

Axis		Force (parallel to axis) symbol	Moment about axis			Angle		Velocities	
Designation	Symbol		Designation	Symbol	Positive direction	Designation	Symbol	Linear (component along axis)	Angular
Longitudinal	X	X	rolling	L	$Y \longrightarrow Z$	roll	ϕ	u	p
Lateral	Y	Y	pitching	M	$Z \longrightarrow X$	pitch	θ	v	q
Normal	Z	Z	yawing	N	$X \longrightarrow Y$	yaw	ψ	w	r

Absolute coefficients of moment

$$C_l=\frac{L}{qbS} \qquad C_m=\frac{M}{qcS} \qquad C_n=\frac{N}{qbS}$$

Angle of set of control surface (relative to neutral position), δ. (Indicate surface by proper subscript.)

4. PROPELLER SYMBOLS

D, Diameter.
p, Geometric pitch.
p/D, Pitch ratio.
V', Inflow velocity.
V_s, Slipstream velocity.
T, Thrust, absolute coefficient $C_T=\dfrac{T}{\rho n^2 D^4}$
Q, Torque, absolute coefficient $C_Q=\dfrac{Q}{\rho n^2 D^5}$

P, Power, absolute coefficient $C_P=\dfrac{P}{\rho n^3 D^5}$.
C_s, Speed power coefficient $=\sqrt[5]{\dfrac{\rho V^5}{P n^2}}$.
η, Efficiency.
n, Revolutions per second, r. p. s.
Φ, Effective helix angle $=\tan^{-1}\left(\dfrac{V}{2\pi rn}\right)$

5. NUMERICAL RELATIONS

1 hp = 76.04 kg/m/s = 550 lb./ft./sec.
1 kg/m/s = 0.01315 hp
1 mi./hr. = 0.44704 m/s
1 m/s = 2.23693 mi./hr.

1 lb. = 0.4535924277 kg
1 kg = 2.2046224 lb.
1 mi. = 1609.35 m = 5280 ft.
1 m = 3.2808333 ft.